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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND B. ALFRED RAWORTH.

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VOL. CIII.—No. 2672.] *LONDON: FRIDAY, MARCH 16, 1917.* [*Registered at the General Post Office as a Newspaper.*] [PRICE 9d. BY INLAND POST..10d.

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For Boilers of all types.
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Naval Outfits a Speciality.
4078

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See their Illus. Advertisement page 107, last week.

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See page M, March 9. 5734

Improved High Pressure
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See Advertisement page 7. 5707

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200 KW. GENERATING SET, enclosed High Speed Engine, two phase, 50 periods, 2,500 volts.
52 HP. MOTOR, three phase, 800 r.p.m.
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Fine Red Moulding Sand,
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"THE FIRM WHO GAVE THE FLYING BOAT TO THE NAVY."
ALL BRITISH BUILT.
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See half-page Advertisement, last and next week.

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SYPHONIA STEAM TRAPS. REDUCING VALVES.
High-class GUNMETAL STEAM FITTINGS.
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See Full Page Advt. page 66, March 9.

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SPECIALISTS, 4794
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Address, BURNETT AVENUE, HULL.
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WORK of all description undertaken for Manufacturers, Patentees, &c. Also repairs and renewals. Best work, moderate charges.—ROSSER & RUSSELL LTD., Queen's Wharf, Hammersmith.
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Destroyers, Torpedo Boats, Yachts and Fast Boats. Submarine and Submersible Boats.
NORMAND'S Patent Water-tube Boilers, Coal or Oil Heating. Diesel Oil Engines.

Centrifugals.
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Pott, Cassels & Williamson,
MOTHERWELL, SCOTLAND.
5402
See half-page Advertisement page 73, Feb. 23.

The Manchester Steam Users' ASSOCIATION.

For the Prevention of Steam Boiler Explosions and for the Attainment of Economy in the Application of Steam. 9, MOUNT STREET, MANCHESTER.

Chief Engineer: C. E. STROMEYER, M.I.C.E.

Founded 1854 by Sir W. FAIRBAIRN.

Certificates of Safety issued under the Factory and Workshops Act, 1901. Compensation for Damages and Liabilities paid in case of Explosions. Engines and Boilers inspected during construction. 5884

MINISTRY OF MUNITIONS OF WAR.

ORDER AS TO PRIORITY.

Whitehall Place, S.W.

February, 1917.

The Minister of Munitions in exercise of the powers conferred upon him by the Defence of the Realm Regulations and all other powers enabling him HEREBY ORDERS and requires that all persons engaged in any of the trades, businesses, or industries specified in the third schedule hereto shall in all respects comply with the following directions and regulations as to the priority to be given to work carried out in their factories and workshops and elsewhere in or in connection with such trades, businesses, or industries or any of them.

(1) Priority shall be given to work in such trades, businesses, and industries in accordance with the classification set out in the first schedule hereto.

(2) All work and orders for work or material undertaken by them shall be divided into three Classes, Class A, Class B, and Class C mentioned in the first schedule.

(3) Work and orders in Class A shall take precedence of work and orders in Class B or Class C, and work and orders in Class B shall take precedence of work and orders in Class C irrespective of the date when the orders were received and of any contractual obligations to the contrary.

(4) Subject to paragraph 7 hereof orders for work shall be treated as belonging to Class A or Class B as the case may be if accompanied by a certificate from the person ordering the same in the form set out in the second schedule hereto, stating that the work belongs to Class A or Class B respectively.

(5) In the case of a person whose production either as regards the whole or a particular part thereof is regulated by specific directions or regulations from any department of the Government, such person shall not in so far as related to the production so regulated act on a certificate presented to him by another person, but must apply for instructions to the department which regulates such production, forwarding to that department the certificate presented. Any order for work which entails the use of materials which are for the time being subject to control by a Government Department, and in respect of which Regulations shall have been issued, must not be carried out until after compliance with the said Regulations.

(6) Any order for work not accompanied by a certificate in the form set out in the second schedule hereto to the effect that the work falls within Class A or Class B shall be treated as an order for work in Class C.

(7) Any particular or special directions or regulations issued in writing by the Minister of Munitions or by any Government Department regulating production as mentioned in paragraph 5 hereof, as to the classification of any work or order or as to the relative urgency of different work or orders belonging to the same class, shall over-ride these general directions and regulations.

As from the date hereof this order shall be substituted for Circular L. 33 as to control of output issued by the Minister of Munitions on the 31st March, 1916, and references to this order and the corresponding clauses herein mentioned shall be substituted in all orders, directions, notices and permits already made or issued by or on behalf of the Minister of Munitions for any references therein to the said Circular L. 33 and the clauses therein mentioned but such substitutions shall not affect the previous operation of the said Circular L. 33 or any of such orders, directions, regulations, notices or permits, or the validity of any action taken under them or any of them or any penalty or punishment incurred in respect of any contravention or failure to comply with the same or any of them or any proceeding or remedy in respect of such penalty or punishment.

And any certificate already issued under the said Circular L. 33 shall so far as the same was properly issued thereunder continue to have the same effect as if this order had never been made.

THE FIRST SCHEDULE ABOVE REFERRED TO CLASSIFICATION OF WORK.

Definition of Class A.

Class A comprises:

Work or material wholly required as a component part of any work or goods to be carried out or supplied under

(a) A Government War Contract which signifies:

1. Any Contract placed by the Admiralty, the War Office, or the Minister of Munitions.

2. Any Contract for Naval or Military Equipment placed by an Allied Government by or with the consent in writing of the Admiralty, the War Office, or the Minister of Munitions.

(b) Certified War work which signifies:

1. Work on a Contract or Order which the Admiralty, the War Office, or the Minister of Munitions has certified in writing to be War or Munitions work.

2. Work which the Minister of Munitions has directed to be treated on an equality with War work.

(c) Merchant shipping work certified in writing by the Board of Trade to be Munitions work.

Definition of Class B.

Class B comprises:

Work or material wholly required for:

(a) Repairs to existing industrial machinery (but not the replacement of old machinery by new) wherever essential to maintain continuity of operation in the United Kingdom.

(b) The maintenance of reasonable stocks of materials or articles necessary as components parts of work or goods to be carried out or supplied under any orders or contracts to be executed under Class A or Class B.

(c) Export orders, certified in writing by the Board of Trade, the Admiralty, the War Office, or the Minister of Munitions to be of sufficient national importance to be specially approved for export to approved destinations and as to which the Minister of Munitions or other Government Department controlling the necessary materials has certified that such materials can be spared.

(d) Contracts or orders certified in writing by the Admiralty, the War Office, or the Minister of Munitions as necessary for the efficient conduct of the war.

(e) Contracts or orders certified in writing by the Director-General of National Service to be of sufficient importance in the national interest to be placed in Class B and as to which the Minister of Munitions or other Government Department controlling the necessary materials has certified that such materials can be spared.

Definition of Class C.

** Class C comprises all work not comprised in Classes A or B.

THE SECOND SCHEDULE ABOVE REFERRED TO.

FORM OF CERTIFICATE.

This Certificate is issued for the purpose of securing priority for the work referred to herein, in pursuance of directions given by the Minister of Munitions under the Defence of the Realm Regulations.

CERTIFICATE.

Firm's Reference No.

Date.....1917.

To:

Messrs.

Order No.

(of ordering firm or establishment)

Quantity and description:

I/We hereby certify that the work or materials described herein are required for the following purposes:

(Here state clearly particulars of the special War, National or other purposes of the order.)

1. As component of the subject matter of a Government Contract bearing the following reference number, viz., No. and to rth purpose of:

2. (If not a direct component of a Government Contract.) For the purpose of:

References:

and for no other purpose: and that such order falls within Class as defined on the back hereof.

I/We hereby declare the above to be a true and accurate statement.

Signed on behalf of

(N.B.—Read carefully definition in First Schedule)

A FALSE DECLARATION ON THIS CERTIFICATE IS AN OFFENCE UNDER THE DEFENCE OF THE REALM REGULATIONS.

The Certificate must be signed by a Partner, Director, Manager, or other responsible official.

To be shown on demand to any Officer appointed by any Government Department.

Copies of this Certificate for use in making applications can be obtained free of charge at any Head Post Office, where supplies will always be available, or by order from any Money Order Office.

THE THIRD SCHEDULE ABOVE REFERRED TO

1. All trades, businesses or industries carried on in any establishment in which directions as to Priority had been issued on or before the date of this order.

2. All trades and manufactures in or of metals, machinery, agricultural implements and vehicles.

3. The repairing of plant for use in industry.

4. Woodworking. Pottery and Glass Trades. Building and Works of Construction. Textile Trades and Manufacture. Linoleum, Oilcloth and Table Baize Manufacture. Rope, Twine, and Line Trades and Manufacture. Coal Tar Products (manufacture of). Dyestuffs (manufacture of). Other Chemical Products (manufacture of). Lubricating Oils; and Other Lubricants (manufacturers of). Oil Seed Crushing. Soap and Candles (manufacture of). Fertilisers (manufacture of). Paints, Colours and Varnishes (manufacture of). Baskets and Wicker Work (manufacture of). Letterpress and Lithographic Printing. Papermaking. Leather Trades and Manufacture. Boot, Shoe and Clog Manufacture. Coke (manufacture of). Rubber Trades and Manufacture. Waterproofing of Fabrics and of Paper. Electricity, Gas and Water Services. Stone, Marble, Granite, and Slate Quarrying, Cutting and Polishing. Bookbinding.

* The consent of these Departments will usually be given through the Commission Internationale de Ravitaillement (the International Commission), India House, Kingsway, London, to whom application should be made for such consent.

** No certificate may be issued for orders in Class C. G 369

Penningtons. — Engineering

Tutors for A.M.I.C.E., A.M.I.M.E. and A.M.I.B.E. Aeronautical Draughtsmanship.—264, Oxford Road, Manchester.

TENDERS.

IN THE MATTER OF THE TRADING WITH THE ENEMY AMENDMENT ACT, 1916.

The PUBLIC TRUSTEE invites

Tenders for the Purchase of

the Whole or any part of 119,660 Shares of £5 each, fully paid, in SIEMENS BROTHERS & COMPANY, LIMITED, vested in him as Custodian by an Order made by the Board of Trade, in pursuance of Section 4 of the Trading with the Enemy Amendment Act, 1916, and dated 9th August, 1916.

The issued capital of the Company consists of 120,000 Shares of £5 each, fully paid.

The purchasers, who must be British-born subjects, will be required to make a sworn Declaration as to nationality and freedom from foreign control on a form to be obtained from the Offices of the Public Trustee.

The purchasers will also be required to satisfy the Public Trustee as to their financial and technical ability to carry on the business of the Company as efficiently as heretofore, or otherwise to the satisfaction of the Government.

A report upon the Company's operations and affairs has been prepared by the Company, in conjunction with the Company's Auditors (Messrs. PRICE, WATERHOUSE & Co.), and with Messrs. TURQUAND, YOUNGS & Co. Copies of this report can be obtained, subject as hereinafter mentioned, together with copies of Company's accounts up to the 31st December, 1915, at the Offices of the Public Trustee, Kingsway, W.C. All applicants will be required to satisfy the Public Trustee as to any matter which he may think fit to investigate before copies of said report or accounts will be supplied.

Intending Tenderers who desire to inspect the property of the Company, should apply to the Public Trustee for an authority to do so.

Tenders must be delivered, sealed, to the Public Trustee, Kingsway, W.C., on or before Monday, the 2nd day of April, 1917, at Twelve o'clock Noon, and marked on the envelope, "Tender, Siemens Shares."

The Public Trustee does not bind himself to accept any Tender, and reserves to himself all rights in connection therewith.

Forms of Tender can be obtained from the PUBLIC TRUSTEE.

Dated this 8th day of February, 1917. G 106

C. J. STEWART, Public Trustee,
Custodian for England and Wales.

DE SILVA & WALLACE, LIMITED (IN LIQUIDATION).

The RECEIVER of DE SILVA & WALLACE LIMITED (in Liquidation) invites

Tenders for the Purchase of

the BUSINESS as a going concern. The assets to be sold (subject to the sanction of the Ministry of Munitions) comprise the Plant, Machinery, Stock-in-Trade and a Motor Car, and various Fixtures and Fittings, particulars of which are set out below, together with Goodwill and two Leases, as follows:—

1. Lease of 10, Princess Mews, Hampstead, N.W., held for an unexpired term of 46½ years at a ground rent of £9.
2. Lease of Belsize Place, Hampstead, N.W., expiring 24th June, 1918, at a rental of £55.

Further particulars can be obtained from the Receiver, ROBERTSON LAWSON, Chartered Accountant, 60, London Wall, E.C., to whom Tenders in writing should be delivered not later than Monday, 26th March, 1917. The Receiver does not bind himself to accept any Tender, and reserves to himself all rights in connection therewith. Forms of Tender can be obtained from the Receiver on application in writing.

PARTICULARS.

Three Electric Motors, Wiring, Switches, Shafting, Belting, Pulleys, Countershafts, two Engine Lathes, three Cadstan Lathes, one Webster and Bennett Lathe, one Bickford Milling Machine, one Sensitive Drilling Machine, one Bench ditto, one Machine Saw, three Grinders, Gas Forge, Benches, Vices, quantity of small tools, Chucks, Drills, Taps, Dies, &c., Precision Instruments, a quantity of Oils, Greases, Nuts and Bolts and General Stores; Office Furniture, comprising Desks, Tables, Chairs, Safe, Typewriter, &c. G 386

APPOINTMENTS OPEN.

Brass Founding.—Works

Manager Wanted, 6 o'clock man having thorough practical and up-to-date knowledge of Brass Founding, heavy and light, Brass Finishing, Light Engineering and Coppersmith work; also Modern Workshop Management. Apply stating age, experience, salary wanted and when disengaged to "BRASS," WILLIAM PORTEOUS & Co., Advertising Agents, Glasgow. G350

Works Superintendent or

ASSISTANT WORKS MANAGER REQUIRED by large well-known firm, Government controlled, making large and small engines, repetition and general work. Applications will only be considered from experienced engineers thoroughly conversant with latest manufacturing methods and who have made good in every way in similar position in large works. Permanent position to right man. State age, experience, and salary required. No one employed on Government work will be engaged.—Apply your nearest EMPLOYMENT EXCHANGE mentioning this Journal and A 2998. G 344

First-class Experienced

ESTIMATOR WANTED by Government controlled works making large and small engines, repetition and general work; man with thorough practical knowledge of machining and fitting, &c., who could control rate-fixing, progress, and demonstration. Only men thoroughly experienced need apply. Permanent position to suitable man. State age, experience, and salary required. No one employed on Government work will be engaged.—Apply your nearest EMPLOYMENT EXCHANGE mentioning this Journal and A 2997. G 345

Chemist.—Thoroughly Quali-

fied and experienced Steelworks CHEMIST WANTED. Highest grade steels for projectiles, all classes of castings, tools, dies, ball-bearings. State particulars of experience, age, present employment and salary expected. No one already on Government work need apply.—Apply, your nearest EMPLOYMENT LABOUR EXCHANGE, mentioning No. A 3036. G 336

Superintendent Rate Fixer, for

bench work in aeroplane factory N.W. London district. No one residing more than 10 miles away or already on Government work need apply.—Address, G 373, Offices of ENGINEERING.

Chief Rate Fixer Wanted, in

connection with premium bonus system, for large shipbuilding and engineering establishment. No person already engaged on Government work will be engaged.—Apply, stating full particulars, present position, age, and salary required, your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and G 356.

Large Engineering Firm,

Government controlled, REQUIRE the SERVICES of thoroughly experienced WORKS ENGINEER used to lay-out, erection, and complete equipment of up-to-date works; well versed in modern machining and manufacturing methods and the upkeep of plant for maximum output. Permanency to good man. State age, experience, and salary required. No one employed on Government work will be engaged.—Apply your nearest EMPLOYMENT EXCHANGE mentioning this Journal and A 2969. G 346

Engineer Wanted as Premium

Bonus Rate Fixer for Marine Shop on the Clyde. Liberal salary given to good technical man with experience of machine shop practice. State fully qualifications, age and salary. No one already on Government work need apply.—Apply, your nearest EMPLOYMENT EXCHANGE, mentioning No. A 3018. G 334

Electrical Engineer Required

to take full control of all electrical installations and upkeep in large Government controlled works (bulk of current from Corporation). Applications will only be considered from experienced men who have held similar positions with good records. State age, experience, and salary required. No one employed on Government work will be engaged.—Apply your nearest EMPLOYMENT EXCHANGE mentioning this Journal and A 2996. G 347

Cylinder Sinker.—First-class

BRIDGE ERECTOR WANTED; used to pile screwing and cylinder sinking on Government work within 30 miles of London. No one resident more than 10 miles away nor employed on Government work will be engaged. Must be able to set out and take charge of contract.—Apply, giving full particulars of experience, age, and salary required, to BRAITHWAITE & KIRK, 111, Victoria Street, S.W. G 344

Cost Clerk Wanted (ineligible)

in aircraft factory, to take charge of cost department. Engineering experience necessary. No one employed on Government work will be engaged.—Apply, your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and G 352

Engineering Fitter Wanted

for Engineers' Department of Large London Factory. Must be capable of taking charge of Automatic Machinery. Also to attend to upkeep of Boilers and Piping and general Machinery maintenance. Apply by letter stating wages required, age, experience and qualifications with copies of testimonials to "B.F." c/o Streets, Cornhill, E.C. 3. Only men ineligible for Military Service need apply. G 362

Electrician Wanted for

Engineers' Department of Large London Factory. Must be good workman and having sufficient technical knowledge to take charge of entire Electrical Installation consisting of Motors, Cranes, Lifts, Lighting and other accessories. Good wages for a suitable man.—Apply by letter stating wages required, age, experience and qualifications with copies of testimonials to "E.W." c/o STREETS, Cornhill, E.C. 3. Only men ineligible for Military Service need apply. G 380

TECHNICAL COST ENGINEERS.

Several are Required in

the Ministry of Munitions, preferably with experience as Superintendents in Engineering, Iron and Steel Works, Foundries and other Metal Works.

Applicants must not be under 21 years of age and should write in the first instance detailing nature of experience, addressing

D.F.A., Room 467,
Hotel Metropole,
London, S.W. G 351

Wanted, Thoroughly Experi-

enced ENGINEER, to take charge of vertical marine oil engine dept.—Address, giving full particulars, to G 349, Offices of ENGINEERING.

Assistant Electrical En-

GINEERS REQUIRED, to work 8-hour shifts and take charge of complete electrical equipment in important Government factory. Only men having sound technical training and practical experience, not already engaged on Government work need apply.—Applicants should state age and salary required.—Apply, your nearest EMPLOYMENT EXCHANGE, mentioning No. A 3043. G 350

Power Plant Engineer.—

ENGINEER REQUIRED to take charge under Chief Engineer of Steam, Gas and Power Plant in large controlled factory. Applicants must have experience of hand-stoked boilers, and should preferably have B.O.T. certificate. Permanency. State age, experience and salary required. No one on Government work will be engaged without present employer's consent.—Address, G 374, Offices of ENGINEERING.

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DRAUGHTSMEN, for controlled Constructional Engineer's Drawing Office. Architectural or general engineering experience will be considered. State age, salary required, and forward references. Must be ineligible for military service. No person already on Government work will be engaged.—Apply to your nearest EMPLOYMENT EXCHANGE, mentioning A 3024. G 346

Steel Foundry—Working

Drawings or Services of Qualified Engineer Wanted for the construction of 8-ton Siemens open hearth Steel Melting Furnace, producers and equipment in accordance with the latest, most approved practice. Apply stating particulars and terms. No one already on Government Work need apply. Apply your nearest EMPLOYMENT EXCHANGE mentioning No. A 3043. G 353

Foreman, to Boss Repair Squad

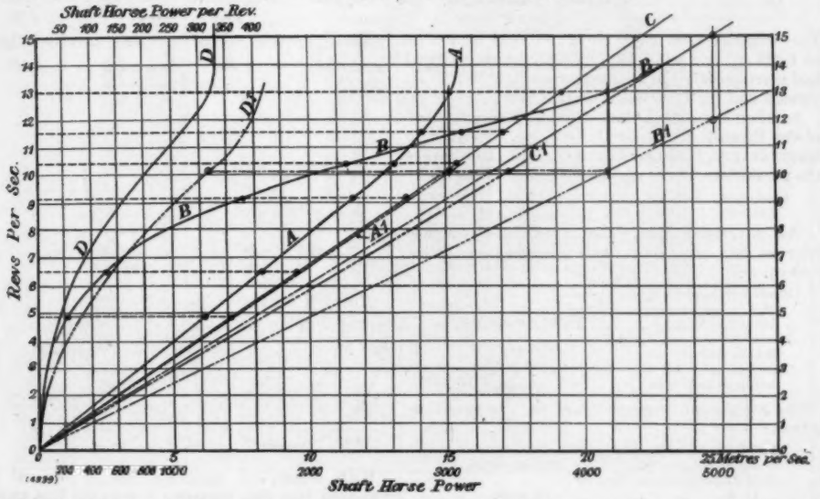
and to responsible for all machinery in steel works near Glasgow. An all round knowledge of engineering and the care of engines and boilers essential. State very full particulars and salary expected, in confidence. No one already on Government work need apply.—Apply your nearest EMPLOYMENT EXCHANGE, mentioning No. A 3034. G 351

ON CAVITATION: A STUDY OF THE SCREW-PROPELLER.

By C. H. HOLST.

THE following notes are the result of a study of the data obtained from the progressive trials of a certain torpedo-boat destroyer, this being one of a number of similar studies, made with the special view of obtaining more detailed information about the questions relating to the action of ships' screws. In the accompanying diagram, Fig. 1. the black dots shown on the dotted horizontal lines indicate the data which were obtained from the trial results, and curves are drawn through these black dots to find the intermediate values, as is usually done in practice.

The curve A A indicates the velocity of the vessel expressed in metres per second. That marked B B B indicates the corresponding number of shaft horse-power delivered to each of the vessel's propellers, while the straight line C indicates the value of "pitch" per second, expressed in metres, this value being obtained by multiplying the "pitch" of the propeller by the number of revolutions per second, corresponding to either "velocity of ship" or "shaft horse-power" shown in the two first curves. Dividing the total number of shaft horse-power by each separate number of revolutions per second, a new curve D D is easily set out, representing graphically the number of shaft horse-power required per revolution per second of the propeller. This curve is thus in true accordance with the published trial results.



An examination of these curves leads to some conclusions which, according to my views, throw considerable light on certain questions concerning propeller action, and it is this examination and its consequences to which I desire to call attention.

To begin with the curve A. Up to fully 9 revolutions per second the curve is a nearly straight line, diverging from the straight line C, in a nearly constant proportion, and indicating that the ratio between "pitch per second" and ship's velocity per second remains nearly constant up to that limit—in other words, it indicates a nearly constant percentage of "slip." But at an increasing number of revolutions per second the curve A plainly indicates an abnormal augmentation of this "slip" percentage until, between 13 and 14 revolutions per second, the curve, having changed nearly into the vertical direction, points to such a slow increase in velocity, when compared with the continuously increasing line of values for "pitch per second," that the conclusion is evident that, however the number of revolutions may increase, the velocity of the vessel will not increase at all, or very insignificantly only.

Examining curve B B in its lower part, we shall see that the values for shaft horse-power originally increase at a ratio of nearly the cube of the number of revolutions; for instance, 420 shaft horse-power at 6 revolutions and 3,400 shaft horse-power at 12 revolutions, 250 shaft horse-power at 5 revolutions and 2,000 shaft horse-power at 10 revolutions, an increase which corresponds fairly with the general assumptions. But instead of going on at the same ratio, in comparing 7 with 14 revolutions, we shall find, from the trial data, 630 shaft horse-power at 7, against only 4,600 shaft horse-power at the higher number of revolutions, and thus the curve of total horse-power, in showing the tendency to become a tangent to the broken straight line drawn from B to the zero point, indicates that the maximum power of engines per revolution is being reached.

There can be no doubt that this change in the direction of curve B, as well as of curve D, must take place. When, and as soon as, the maximum of steam pressure is reached in the cylinders of a reciprocating engine, or the maximum of impulse in a steam turbine, *the power per revolution* cannot be increased, any subsequent increase in power can only follow from an increased number of revolutions per second, and this increase is only proportionate to the "first power" of the changing number of revolutions instead of to the cube.

The propeller, however, as shown by curves A and C, is acting under quite different conditions. At every increase in number of revolutions its "pitch per second" increases in direct proportion, and that fraction of "pitch per second" which represents the velocity of the ship ceases to increase, or increases only very slowly.

But, then, that part of "pitch per second" which is termed "slip" increases enormously, and as "slip," according to the author's views, must be a measure of, or bear a certain proportion to, "the pressure exerted by the propeller to drive the ship ahead," this "pressure" must also increase enormously with the increasing slip.

Perhaps it will be necessary to explain this more fully before going further. The power of any engine is to be expressed in the product of so many tons of pressure of any kind, exerted over so many metres per second, resulting in so many metre-tons, equivalent to so many horse-power, 1 horse-power being equal to 0.075 metre-ton or to 75 metre-kilogrammes per second.

The same units must be used when dealing with power-absorbing instruments, such as ship's propellers for instance, and thus the work required to drive a propeller, and by means of that propeller to drive a ship, may be and must be expressed in so many tons of pressure exerted over so many metres, this latter value being the distance covered by the ship in one second.

Other studies on this same subject have enabled the author to determine accurately the amount of this pressure under various conditions, but it is evident that this pressure in question can never have a greater value than that found by dividing the number of metre tons corresponding to engine power by the number of metres of ship's velocity per second. It has been stated that on "nearing cavitation" a screw propeller attains a maximum of effect—and from this statement we may conclude that in this present example the maximum to be expected may be approximated as follows:—

Maximum shaft horse power per revolution to be obtained from engines ...	330 s.h.p.
Equal to 330 by 0.075 ...	25 m.-tons.
At 14 revolutions per second, 25 by 14	350 „
Maximum speed of ship per second	15.40 m.
Thus maximum pressure to be expected, 350 ÷ 15.4 m. per second	22.70 tons.

but also:

25 m. tons at 15 revolutions per second will give ...	375 m.-tons.
Maximum speed of ship remaining	15.40 m.
Thus maximum pressure to be expected, 375 ÷ 15.4 m. per second	24.30 tons.
And at 16 revolutions per second, according to same reasoning	400 m.-tons.
And maximum pressure to be expected, 400 ÷ 15.4 ...	26 tons.

From the above we may conclude that the engine power, as increasing with the number of revolutions, is being absorbed by causing a "slip" producing "pressures per unit" of an increasing magnitude, and, further, that "if such increasing pressures per unit do not produce a greater speed of the ship, the number of units on which this pressure acts must decrease proportionately," so that a nearly constant value of "total pressure" is obtained, always equal in certain proportion to the resistance of the ship.

This condition can only be fulfilled when the active blade surface of the propeller is gradually diminishing—as it will be—by a gradually diminishing annular surface of the propeller, caused by want of engine power to drive the water, at the corresponding speed, through the original annular space. This original annular space is the "disc area" of propeller minus area of boss. The author's assumption is that the action of the propeller, when nearing the limit of "cavitation," is such as to automatically increase the diameter of this inner ring until, the diameter of outer and inner ring becoming equal, there remains no blade surface to act upon, however high the pressure per unit of surface has been just before, when that pressure, acting only on the outer tips of the blades, was as yet equal to what would have been a normal pressure on the full original surface of the blades.

Some evidences in favour of the views explained above may here follow. Supposing the same vessel had been fitted with engines capable of developing the same value of shaft horse-power at 12 revolutions per second as the original engines at 15 revolutions per second, then the line B1 zero would show the maximum of power to be obtained at any number of revolutions.

The same ship, requiring the same power to go the same speed, would then go 15.2 metres per second at 10.15 revolutions of engines, as shown graphically by A1, and the curve D1 shows the increased values of shaft horse-power per revolution of the heavier type of engine.

Naturally this engine would require a propeller of different pitch, were it only to secure a "pitch per second" which, apart from any fixed or arbitrary percentage of "slip," must at least be something in excess of the vessel's speed. The straight line C1 gives the "pitch" per second for a propeller with a "slip" equal to that of the former screw in its lower numbers of revolutions, the horizontal distances between A and C being the same as between A1 and C1.

A propeller of that "pitch per second" will continue to work, under the assumed conditions of engine power and speed, at 10.15 revolutions per second, "without any reduction of its original blade area," whereas calculations, based on the principles explained above, have shown that the particular propeller here described only worked at the diminishing areas shown in Table I, subjoined, 1.35 sq. m. being the original value:—

TABLE I.

At 6 revolutions, 1.35 sq. m.:	
Pressure per unit 2.97 tons	4.02 tons.
4.02 tons by 7.60 m. speed	30.5 m.-tons.
30.5 m.-tons being equal to	408 s.h.p.
Or 68 s.h.p. per revolution.	
At 8 revolutions, 1.35 sq. m.:	
Pressure per unit 5.240 tons	7.33 tons.

TABLE I.—*continued.*

7.33 tons by 10.10 m. per second	74 m.-tons.
74 m.-tons being equal to	990 s.h.p.
Or 124 s.h.p. per revolution.	
At 10 revolutions, 1.35 sq. m. :	
Pressure per unit 8.880 tons	12 tons.
12 tons by 12.60 m. per second	151 m.-tons.
151 m.-tons. being equal to	2,010 s.h.p.
Or 201 s.h.p. per revolution.	
At 11 revolutions, 1.24 sq. m. :	
Pressure per unit 12.100 tons by 1.24	15 tons.
15 tons by 13.65 m. per second	205 m.-tons.
205 m.-tons being equal to	2,680 s.h.p.
Or 244 s.h.p. per revolution.	
At 12 revolutions, 1.04 sq. m. :	
Pressure per unit 17.100 tons by 1.04	17.800 tons.
17.8 tons by 14.52 m. per second	257 m.-tons.
257 m.-tons being equal to	3,432 s.h.p.
Or 286 s.h.p. per revolution.	
At 13 revolutions, 0.70 sq. m. :	
Pressure per unit 29.700 tons by 0.70	20.7 tons.
20.7 tons by 15.2 m. per second	315.5 m.-tons.
315.5 m.-tons being equal to	4,200 s.h.p.
Or 322 s.h.p. per revolution.	
At 14 revolutions, 0.465 sq. m. :	
Pressure per unit 48.5 tons by 0.465	22.4 tons.
22.4 tons by 15.4 m. per second	345 m.-tons.
345 m.-tons being equal to	4,600 s.h.p.
Or 328 s.h.p. per revolution.	
At 15 revolutions, 0.298 sq. m. :	
Pressure per unit 81.5 tons by 0.298	24.2 tons.
24.2 tons by 15.4 m. per second	372 m.-tons.
372 m.-tons being equal to	4,960 s.h.p.
Or 330 s.h.p. per revolution.	

Thus we find that the original blade surface of 1.35 sq. m. has been gradually reduced to 0.298 sq. m. when running at 15 revolutions per second, which means, for the screw propeller chosen here as an example, that with the outer diameter of 1.60 metres the inner diameter of the annular space has increased from that of the boss or 0.40 metre to 1.38 metres, thus leaving as active part of the blades only a width of 0.11 metres from the outer tips.

This changing of conditions must explain, according to the author's views, the cause of "cavitation," as at a still greater number of revolutions these last 11 centimetres will also become inactive and "cavitation" must take place.

What then happens about the propeller will be, as the author is led to believe, not the entering of air into the sphere of propeller action, but the flow of a stream of water through the propeller at such a velocity that, "being equal to the velocity of the propeller," no pressure can be obtained by the difference, which has produced the effect up to this critical point. Very likely the next moment to that in which "cavitation" begins the water surrounding the propeller will be "churned," as it were, by the propeller blades, and this "churning" will necessarily cause a mixture of water and air, as is to be observed in all cases where propellers are being driven at speeds not corresponding with the ship's velocity, *i.e.*, when a ship is trying her engines while moored to a quay, or when the engines are going astern while the ship is still making headway.

This gradual widening of the boss of a propeller into an annular surface inside the screw disc is met with in a great many cases of propellers which the author has been able to examine, and the example given in the preceding lines does not stand alone in its kind. It was chosen simply because, by dealing with a full set of data of a "progressive trial" for this given propeller, the process described may be followed, as it were, step by step.

Other propellers give similar indications of working with a reduced blade area quite independent from the values of their respective diameters, or surfaces, or pitches, or from the total amount of horse-power transmitted, but they all invariably show the same symptoms from the moment the number of horse-power per revolution becomes insufficient to throw the water backwards through the full area of propeller disc area less boss area.

It may be interesting to give some more particulars about the propellers above referred to. The one which was discussed first had the following leading dimensions :—

Diameter, 1.60 m.; pitch, 1.48 m. Three blades.	
Developed area in total ...	1.35 sq. m.
Shaft horse-power transmitted at 13 revolutions per second	4.200 h.p.

Another example was furnished by the following :

Diameter, 2.35 m.; pitch, 2.08 m. Three blades.	
Developed area in total ...	3.05 sq. m.
Shaft horse-power transmitted at 9.35 revolutions per second	9.320 h.p.
Shaft horse-power per revolution per second	1.000 h.p.

The velocity of the ship in this case was equal to 15.20 m. per second, as in the first case considered. The maximum pressure to be given by this screw is thus found as follows :—

9.321 shaft horse-power is equal to	700 m.-tons.
700 m.-tons divided by ship's velocity = 700 ÷ 15.2, gives pressure	46 tons.
Pitch per second 2.08 by 9.35 revolutions per second ...	19.45 m.
The ship's velocity was equal to	15.20 m.
Leaving for value of "slip" ...	4.25 m. per sec.
Producing a pressure per square metre...	33 tons.
And requiring a blade area of	1.385 sq. m.
To produce a total pressure of	46 tons.

The original area thus being reduced from 3.05 to 1.385 sq. m., being 48½ per cent. of the original and corresponding to an annular surface of 2.35 m. outside and 1.276 m. inside diameter.

Another example is furnished by the propellers of the Spanish destroyer Bustamente, described in ENGINEERING, February 11 and 18, 1916. In this case the particulars of the propellers are as follow :—

Diameter, 1.28 m.; pitch, 1.14 m. Three blades.	

The developed area is not given in the article referred to, but may be evaluated at about 0.60 sq. m.

Shaft horse-power transmitted at 17.65 revolutions per second	3,006 s.h.p.
Shaft horse-power per revolution per second	170 h.p.
The velocity of the vessel being in this case	15 m. per sec.

The maximum pressure may be computed as follows :—

3,006 shaft horse-power is equal to	225 m.-tons.
And 225 m.-tons divided by 15 m.	15 tons.
Pitch per second, 1.14 m. × 17.65 revolutions ...	20.12 m.
Leaving for value of "slip" 20.12 — 15	5.12 m.
Producing a pressure per square metre of ...	48 tons.
And requiring a blade area of only	0.313 sq. m.
To produce the available maximum of	15 tons.

If the original evaluation of 0.60 sq. m. has been correct this original area is reduced by nearly 50 per cent., the disc area being in this case reduced to an annular area having an outer diameter of 1.22 m. and an inner diameter of 0.85 m.

Perhaps still more remarkable evidence is found by analysing the communication of Captain Dyson, of the United States Navy, which was published in *Shipbuilding and Shipping Record* of March 9, 1916, where two three-bladed propellers are described, having very slight differences in dimensions, and producing widely different numbers of revolutions when transmitting the same power, and driving two exactly similar ships at the same speed.

The propellers are illustrated in Fig. 2 subjoined and the chief data are given in Table II. From these data we find the results given in Table III, corresponding in both cases with the reduction of active blade area.

TABLE II.

	Propeller No. 1.	Propeller No. 2.
Diameter	2.32 m.	2.35 m.
Pitch	1.98 m.	2.03 m.
Number of blades ...	3	3
Developed surface ...	2.58 sq. m.	2.62 sq. m.
Revs. per minute ...	611 or 10.183 per sec.	564 or 9.4 per sec.

TABLE II—*continued.*

	Propeller No. 1.	Propeller No. 2.
Shaft h.p. transmitted ...	8,000	8,000
Shaft h.p. per revolution per second	785	850
Velocity of ship ...	15 m. per sec.	15 m. per sec.

TABLE III.

	Propeller No. 1.	Propeller No. 2.
8,000 shaft horse-power is equal to ...	600 m.-tons.	600 m.-tons.
Velocity of ship ...	15 m. per sec.	15 m. per sec.
Maximum pressure ...	40 tons.	40 tons.
Pitch per second ...	20.19 m.	19.08 m.
Leaving "slip" per second	5.19 m.	4.08 m.
Producing a pressure per sq. m. of	49.5 tons.	30.6 tons.
And requiring a blade area of	0.81 sq. m.	1.315 sq. m.
To produce the total of...	40 tons	40 tons.
The reduction of blade surface thus amounts to (of the original) ...	31.25 per cent.	50 per cent.
The diameter of outer circle of annular space remains	2.32 m.	2.35 m.
The inner diameter being	1.83 m.	1.36 m.

PROPELLER N°1	PROPELLER N°2.
Outer Dia. ..... 2.32 M	*Outer Dia.* ..... 2.35 M.
Inner " ..... 1.83 "	*Inner* " ..... 1.36 "
Original Surface 2.58 M²	*Original Surface* 2.62 M²
Reduced " 0.81 "	*Reduced* " 1.315 "

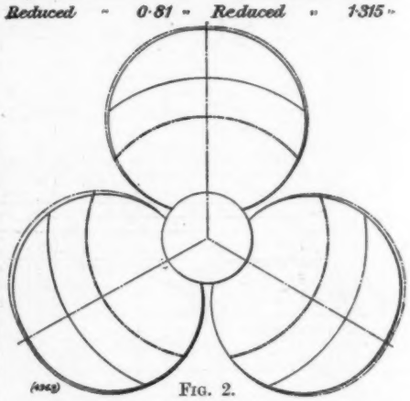


FIG. 2.

With regard to propeller No. 1 it must be remarked that this propeller is working just at the limit of cavitation, as there is no perceptible difference to be found at an increasing or diminishing number of revolutions of engines.

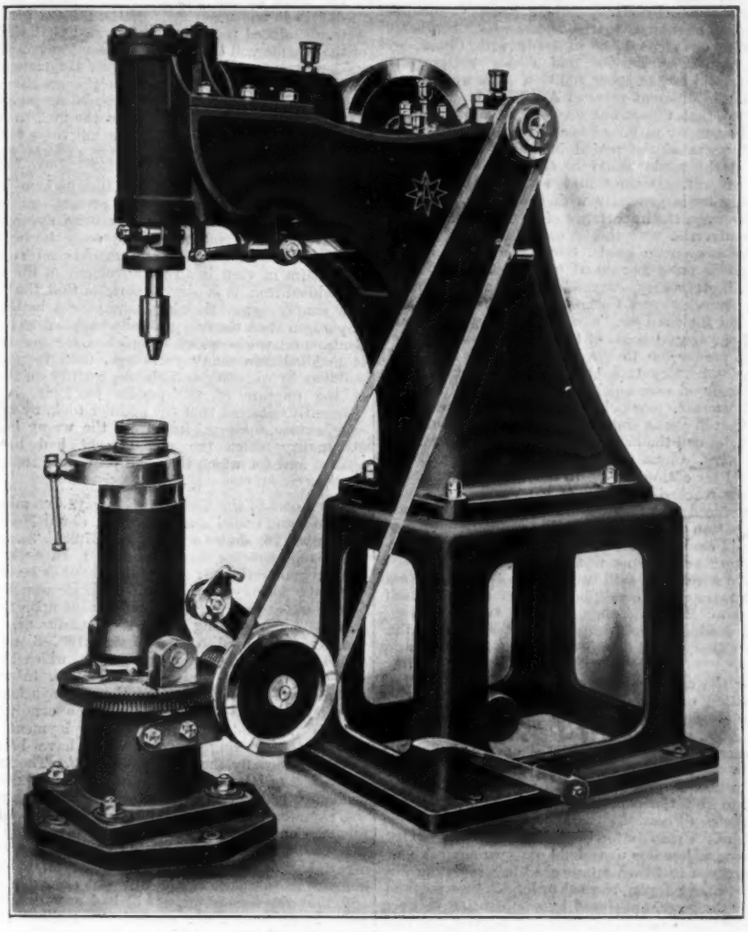
At 11 revolutions per second the same total pressure of 40 tons is obtained with a "slip" per second of 6.75 m., producing a pressure per sq. m. of 84 tons and requiring a blade area of 0.48 sq. m. only, whereas the same pressure is obtained at 10 revolutions per second with a "slip" of 3.80 m., producing a pressure per sq. m. of 42.4 tons, and thus requiring a blade area of 0.95 sq. m. to produce 40 tons total pressure. Within this range the velocity of the vessel and the power of the engines remain absolutely the same, so that it is to be considered as being merely accidental whether the higher or the lower number of revolutions will be made.

The examples given above of propellers working with a reduced area of screw-disc, and with a correspondingly reduced area of blades, may be completed with one more example, showing that this same symptom is met with even at low speeds and with very small engine power.

From the description of Professor Peabody's "Experiments on the Froude," a paper read before the meeting of the Society of Naval Architects and Mechanical Engineers, held at New York, November 16 and 17, 1911, we may take a striking example, by considering the conditions under which the propeller, described as No. 1, was working when driving the model of the United States cruiser Manning at a speed of 7 knots an hour, and thereby transmitting the insignificant power of only 8.25 shaft horse-power. This propeller had the following dimensions :—Diameter, 24 in., or 0.61 m.; pitch, 26.4 in., or 0.67 m.; and a projected blade surface

SHELL-RIVETING HAMMER.

MESSRS. ALLDAYS AND ONIONS PNEUMATIC ENGINEERING CO., LTD., BIRMINGHAM.



of 61 per cent. of the disc area, equal to 0.176 sq. m.

Following the same reasoning as before we find:—

Number of kilogramme-metres per second	620 kg.-m.
Velocity of ship per second ...	3.6 m.
Maximum pressure to be expected	172 kg.
Pitch per second at 395 r.p.m. ...	4.40 m.
Leaving a slip per second equal to	0.80 m.
This slip producing a pressure per square m. equal to	2.080 kg.
And requiring a blade surface of only	0.083 sq. m.
To produce the total pressure of...	172 kg.

The developed blade surface was thus reduced to 48 per cent. of the original projected surface, and this surface is found by calculation to lie between:—

The outer diameter of the propeller	0.61 m.
And an inner diameter of ...	0.36 m.
Corresponding with the blade surface of	0.083 sq. m.

according to the drawing of the propeller annexed to the description of these experiments.

It will perhaps be necessary to point out that the values found for what is here called "the possible maximum pressure," and obtained simply by dividing the number of kilogramme-metres per second transmitted to the shaft by the ship's velocity in metres per second, is not equal, and cannot be equal, to the actual "thrust" produced by the propeller. The actual thrust, *i.e.*, the pressure produced in the direction of the advance of the ship, and thus in the direction of the propeller shaft, has a value which, being always smaller than this "possible maximum pressure," depends on the combined influences of diameter, number of revolutions and slip in any separate case.

For the present it has only been the author's object to produce some examples of results obtained with his method of investigation, by means of calculation, and to demonstrate by the foregoing that this method gives such results as correspond with established facts met with in practice.

Practice has proved, for instance, that it requires 8,000 shaft horse-power to turn the propellers referred to in Captain Dyson's article respectively at 611 and 564 r.p.m., when these propellers are fitted to similar boats, having a velocity of 15 m. per second, corresponding with that power, and practice has also proved that it requires 8.25 shaft horse-power to turn the propeller of Professor Peabody's model boat at 395 r.p.m., when fitted to the model having a velocity of 3.60 m. per second, corresponding with that power.

Practice, again, has proved that the propeller dealt with in the first part of this study required "so many" shaft horse-power to turn at "so many" revolutions, when fitted to a boat attaining subsequent velocities of "so many" metres per second, and calculations "based" on other figures, or giving other figures as "results," would be worthless.

The calculations should correspond with the facts with an "accuracy" of 100 per cent., as only if this result of accuracy is obtained can such calculations be accepted as being trustworthy, and suitable for being used as a base for further investigations. It is this accuracy which is claimed by the author of this study, and it is his object to point out in subsequent articles that this same method has been invariably adhered to when trying to explain whatever facts are stated in and by actual practice.

The foregoing article deals only with the question "How much power is required to turn a given screw-propeller under various conditions?" Another and quite separate question is to be answered when studying "How much power is required to drive a given ship by means of that propeller?" In other words, there is a difference, and sometimes a very considerable difference, between shaft horse-power and effective horse-power to be taken into account. This fact is without any doubt also one of the facts proved by practice.

SHELL-RIVETING HAMMER.

THE annexed illustration shows a shell-riveting hammer constructed by Messrs. Alldays and Onions Pneumatic Engineering Company, Limited, Birmingham. It will be seen that the hammer is one of the well-known pneumatic type. There is a horizontal cylinder, in which works a trunk piston, driven by a connecting rod from the crankshaft at the back of the machine. This piston serves to compress the air which is used, in the vertical cylinder in front, as the source of motive power. The air is controlled by a valve worked from a foot-lever, and the blows can be varied from the heaviest for which the machine is designed to light feathery taps, which leave a specially good finish. The act of putting the belt on to the fast pulley causes the hammer piston to rise to the top of its stroke, and thus to leave a clear space above the anvil. This latter part, which is seen on the left-hand side of the illustration, comprises a shell-holder, which, of course, is bored to fit the particular shell to be operated on. Different sizes of holder can be fitted to the machine according as it is desired to treat 3-in., 4½-in. or 6-in. shells. The holder is carried on trunnions, and by means of a cam, shown at the left, it can be tilted to facilitate the insertion or removal of a shell. When the shell is in place it is held securely by the clamp shown, and at the same time a steel wedge is placed under the anvil to make it perfectly rigid. During treatment the shell holder, with the shell, is rotated by means of a worm and worm gear, driven by a belt from the end of the crankshaft. We are informed that the hammer will close a base-plate in a 3.3-in. high explosive shell in 20 seconds, including the handling, and a 4.5-in. shell in 30 seconds. Apart from its use in closing shells the hammer is available for a large number of uses in connection with planishing and setting brass and copper sheets, and light steel sheets for many purposes.

STRUCTURAL DESIGN.—Mr. C. G. D. Burdett lectured on Friday, February 23, before the Junior Institution of Engineers, on "Structural Design." After a few remarks as to theory *versus* practice—the pure theorist being liable to design elaborate and costly structures, while the practical man must have some theory as a basis for his work—the author passed on to specific structural details, points to be observed and practice to be avoided. By the aid of the blackboard he dealt with such details as:—Uniform pressure upon footings to be obtained as nearly as possible. The usually accepted formula for load over "lintels" as being equal to weight of brickwork contained within an equilateral triangle whose bases equal span of opening was discussed and shown to be open to question. Disposition of rivets and gusset-plate connecting members of roof trusses, bridge girders, &c. Rivets, he held, should not be put in tension, and should always have plenty of metal in them before closing, to form a good, full head; a short rivet allows the hydraulic riveting "set" to bite the plate around the rivet head, and consequently weakens the plate. The practice of jobbing builders, or, as one member remarked, "building jobbers," of securing an H column by only two plain cleats at the web to the baseplate, was condemned. The proper method, the lecturer said, should be to rivet reinforcing plates and cleats to the flanges. An airhole should be drilled in the baseplate to avoid the possibility of air being trapped between it and the concrete footing when grouting in, thus preventing the load from being evenly distributed. Continuous beams were not in favour, as unknown stresses were liable, due to any settlement of individual supports. It was easier, and probably cheaper in the long run, to use, say, three 10-ft. lengths, rather than one 30-ft. length. The question of wind pressure was also discussed. After the collapse of the Tay Bridge experiments on wind pressures were carried out, and as a result 56 lb. per square foot was allowed on structures. This was afterwards reduced to 30 lb., the value now taken. In Germany 26 lb., in the United States of America 20 to 25 lb., is taken. A series of experiments made a few years ago was cited. These were conducted on a shed with artificial wind pressure, and it was found that a "pressure bolster" existed on the windward side and a "suction bolster" on the lee side in the triangular space formed by the shed side, a certain distance out along the ground, and the underside of the main air current, the air current sweeping up, over, and down the other side in stream-line fashion. In the course of the discussion one member quoted the highest record of the Meteorological Office for wind pressure as 23 lb. per square foot, steadily sustained for 1 hour. This was registered at Fleetwood.

INDUSTRIAL NOTES.

THE Minister of Munitions, in exercise of the powers conferred upon him by the Defence of the Realm Acts, the Munitions of War Acts, and all other authorising powers, orders as follows:—(1) All cupro-nickel scrap as hereinafter defined shall as from the 13th day of March (hereinafter called "the appointed day") be dealt with and disposed of in accordance with instructions from time to time given by the Director of Non-Ferrous Rolled Metal Strip and Sheet Supply (E.M.7), Ministry of Munitions, Whitehall Place, London, S.W., on behalf of the Minister, and not otherwise. (2) No person shall as from the appointed day sell, offer for sale, use or otherwise deal with or dispose of any cupro-nickel scrap, whether in pursuance of a contract existing prior to the appointed day or not, except under and in accordance with the terms of a licence granted by the said Director on behalf of the Minister. (3) All persons shall, on or before the 24th day of March, 1917, furnish to the said Director a statement in writing giving particulars of all cupro-nickel scrap in their possession or under their control on the appointed day, and of all their existing contracts and orders for the purchase or sale of cupro-nickel scrap. (4) The term cupro-nickel scrap for the purpose of this Order shall include and mean all kinds of cupro-nickel webbing scrap, process scrap, and swarf and scrap, of whatsoever kind or nature, in the composition of which copper and nickel are included, or any of them. (5) The Minister will subsequently communicate to the owners of cupro-nickel scrap taken over by him the prices which he will be prepared to pay for the same. (6) Any person acting in contravention of or failing to comply with this Order will be guilty of an offence under the Defence of the Realm Regulations, and be liable to penalties of fine and imprisonment.

The Federation of British Industries held its first meeting on the 2nd inst., at Caxton Hall, Westminster. Mr. F. Dudley Docker, C.B., occupied the chair, and stated that the membership of the Federation now reached a total of 269 firms and individuals and 50 associations; 18 applicants were awaiting election, making a total of 337. He referred in the course of his speech to the recent meetings which had been held between representatives of employers and of trade unions with a view to the distribution of labour after the war, and to dealing with any subsequent problem of unemployment or labour dislocation. He was glad to add that the representatives of the employers were members of the Federation. If the Federation, he proceeded, did nothing else but bring capital and labour together, it would be an achievement to be proud of. He ventured to think that the recent meetings in question had had a very good effect, and that the atmosphere of friendliness and co-operation which they had engendered would make subsequent negotiations with labour more easy and more productive. It would be necessary to speak plainly to labour in future, not to be afraid to ask what was wanted, and not to be afraid to give what ought to be given for fear of something more being demanded. The welfare of the Empire was essentially dependent upon the existence of a satisfactory understanding between employers and employed, and he hoped the Federation would play an important part in promoting such an understanding.

In the course of the discussion upon a paper on "German Methods," read by Mr. J. H. Vickery, LL.B., before the Royal Society of Arts, on the 7th inst., Mr. James Swinburne, F.R.S., said many people thought that the Germans were an inventive people, but that was not so; practically the only inventions which came from Germany were in organic chemistry. Their method of working almost precluded them from inventing anything. In the early 'eighties, for instance, America was very active in developing electrical plant and machinery; England was equally active, but was hindered by legislation from doing much in the way of manufacturing. When he (Mr. Swinburne) went over a particular works in Germany, about the year 1890, he found that they had simply taken English and American practices and combined them, selecting the best of each, and in that way they had developed a huge business. With regard to Mr. Vickery's suggestion that some kind of partnership might be made between the British Government and private owners, it seemed to him (Mr. Swinburne) that the powers of the Government should always be kept down as much as possible. In any Government-controlled business the chief places were occupied by politicians and their friends. If any of the members present at the meeting had had much to do with Government offices, they would know that the heads of the different Departments would never take any responsibility. Such things as the Post Office and Telephone Service might be run by the Government, because they would be supposed to be too big to be managed by private individuals; but the financial result of the British Government taking over the telephones was well known. He did not think that the combination of the Government with private owners would tend to sweeten the relations between capital and labour; the Government generally did not get on very well with its workers.

The following is an abstract of an address delivered on the 2nd inst. by Mr. Archibald Rose, Commercial Attaché at Shanghai, to the Manchester Chamber of Commerce on the subject of trade with China, and taken from *The London and China Telegraph*:—Mr. Rose said he had spent eighteen years working and travelling in different parts of Asia, and he was firmly convinced that China was one of the markets which would best repay us for a little care and trouble in the difficult years of the period in which the industrial power of the world would be straining to repair the havoc of war. Dealing first with the outlook for increasing trade generally with China, Mr. Rose laid emphasis upon the importance of advertising. The one way to advertise with the Chinese, he said, was to let the consumer see the goods. Samples would do in some cases, goods on consignment in others, and in other cases still, travellers, or goods on deferred payment. Japan, America and Germany were making a very strong bid for the China market. They worked hard, studied the special needs of their buyers, and cut their costs of production to the lowest possible figure. It should not be forgotten that the Chinese themselves were coming on very quickly as an industrial people.

Mr. Rose made particular reference to the piece-goods trade. Cotton yarns and cotton cloth, he reminded the meeting, headed the list in values of our exports from this country. China was the second biggest market in the world for cotton cloth. In his opinion, she had by no means reached the limit of her consumption. He was convinced that China could take a great deal more of our cotton products, that she would like to have them, and could pay for them. But in order to induce her to do this conditions would have to change in some way. We were faced with two problems—new competition and changing conditions in the country itself. There were, Mr. Rose thought, only two remedies—cheaper production in Lancashire and better distribution in China, mainly with the object of stimulating demand.

As for the conditions of production, he summarised the position of competitors by saying that England could produce for a penny about 7½ lb. of cotton yarn, Japan 11 lb., and China 12 lb. The advantages in the latter cases did not lie entirely in cheap labour, but rather in the fact that both in Japan and China they had been able to produce a cloth which was just good enough to suit the consumer and just cheap enough to compete successfully with a dearer cloth from Lancashire. A remedy for the increasing trade rivalry, one that would enable us to hold our own against competition which had been approached in a scientific way by America and Japan, seemed to him to be a commission, not too large, appointed by co-operation between the master and operative spinners and weavers, the Far-Eastern shippers, the merchants and trade union representatives. The Commission would visit China and Japan for the express purpose of examining the products of local mills, the class of cotton used, and the cotton cloths which were selling best. Such a body of men might possibly decide that it was essential for employers to use and for operatives to work a certain quantity of cotton of inferior staple to that now employed. The proper handling of the China trade was of vital interest both to capital and labour in Lancashire. One thing he believed China could teach us all, as the result of her centuries of experience. She had her guilds and her trade unions, but they were combinations of employers with their employees, not of the one against the other. The Chinese had learnt, and they might help to teach us, the possibility and value of real co-operation. On the troubled question of the distribution of piece-goods in China Mr. Rose attributed the real advantage of non-British competing firms, especially German, to the fact that they had China houses, with their headquarters in China, with responsible partners on the spot who could take prompt decisions and accommodate themselves quickly to any new development. In conclusion, Mr. Rose said:—"A closer co-operation between the producer, the exporter, and the official is perhaps the thing which could help most of all to extend our national trade in China."

We read in *The Birmingham Daily Post* that with the view of stimulating the interest of the men in their work, and at the same time of increasing the output, a scheme has been inaugurated under which it is proposed to offer inducements to operatives in the iron trade to make practical suggestions for the improvement of the present methods of puddling. The matter was first raised by the Board of Education, and it has been passed on to a committee of the British Ironmasters' Association, and sub-committees have been appointed in various parts of the country for giving effect to the scheme. The members of the local committee are Colonel Trinham (Messrs. Hingley and Sons, Wetherton) and Mr. J. Bruce Harding (Messrs. Robert Heath and Sons, Stoke-on-Trent), and they have issued notices for posting in the local iron works calling attention to the scheme.

The work of the puddler is practically the same to-day as it was when most of the present generation were introduced to it, and it is hoped that the result of the scheme will be to bring out some suggestions for its improvement. So far, however, the response has been poor. Though able to supply a graphic verbal description of their views on the puddling process, the nature of their calling does not fit the men to make a great success of essay-writing, but all these facts will be taken into consideration by the experts who will deal with the papers.

The aim referred to in the Birmingham journal, *i.e.*, "the improvement of the present methods of puddling," is rather vague. Strictly speaking, an improvement of methods would seem to be in the province of metallurgists and mechanical engineers. If the aim in view is an improvement in the quality of puddled iron, it is easy to surmise that the puddler may simply suggest that he should have a better grade of pig-iron than the one generally supplied to him. A Continental works which abandoned the manufacture of puddled iron many years ago, used to pay their puddlers by quantity and also by quality on the basis of the fracture of the puddle bar; it, however, frequently occurred that the puddler took, by mistake, or otherwise, some pig-iron from the wrong heap, an eventuality which the management had to guard against and for which they had provided penalties.

The report of the Victorian Railways Commissioners for the year ended June 30, 1916, dated Melbourne, September 16, shows a deficit of 337,952*l.* 3*s.* 3*d.*

The report states that since July 1, 1915, the minimum remuneration for adult labourers has been raised to 8*s.* 6*d.* per day by the grant of an allowance of 6*d.*, or in some cases 1*s.* per day, consequent upon the high cost of living arising from war conditions. Other concessions granted to the staff since 1905–6 amounted in 1915–16 to no less than 752,978*l.*, of which 135,536*l.* was chargeable to capital and 617,442*l.* to working expenses. In other words, if the railways had been operated in 1915–16 under the same conditions as regards pay and conditions of employment as in 1905–6, the working expenses would have been less than was actually the case by 617,442*l.* The increase in the cost of labour, as well as in the price of materials generally, had not been confined to the railways, but was common to practically all trade activities, and the Commissioners felt they could not too strongly stress the point that such increases in outside businesses had invariably been followed by at least an equivalent increase in the price of the different classes of goods, and that the higher wages bill had accordingly been borne by the consumer; whilst in the Railway Department, despite increased wages and improved conditions of employment, which had affected the working expenses to the extent of 617,442*l.*, the freights and fares had actually been decreased by 210,000*l.* in the same period.

Speaking before the Economic Science Section of the Royal Philosophical Society of Glasgow, on the 7th inst., Colonel R. D. M'Ewan dealt with the question of demobilisation. He pointed out that the Army system of disbandment by units would be unsuitable, and said that the replacing of millions of men in productive employment must be largely guided by civilians. The key to the scheme would be a census or register of all men on service. On our present planning depended the future of generations of our people. The nation had, when peace came, not only to disperse the armies, but to reorganise our labour power so that every man and woman would be engaged in productive and profitable industry. The real scheme must be for remobilisation; not the disbandment of armies, but a resumption with the least possible loss of time of industrial mobilisation. The section whose work could stop earliest was munitions, and no branch of the demobilisation scheme required so much forethought. The abnormal wages of the munition worker and the need for absolutely sudden cessation of production raised the most serious dilemma. A strong committee, representative of the Government, employers and labour, should be at work now, studying how the munition works were to be converted for peace industry. Agriculture, said Colonel M'Ewan, would surely absorb many men who formerly were in industrial life, for we had now to utilise scientifically every available acre of our own land for the production at home of our food. It was obvious that aviation would be a practical means of locomotion in the future; the skilful and enterprising young men who had so distinguished themselves at the Front would certainly be pioneers in this direction.

THE OPTICAL SOCIETY.

A MEETING of the Optical Society was held on Thursday, March 8, at Burlington House. The following were elected members of the society:—Mr. Maurice Blood, M.A., Mr. E. B. Knobel, F.R.A.S., Mr. J. H. Leech, Mr. A. S. Newman, Mr. E. H. Smart, and Mr. A. E. Conrady, F.R.A.S. Three communications were considered. Mr. C. L. Redding, chief assistant of the technical optics department, Northampton Polytechnic Institute, explained "*A Simple Method of Determining the Size of the Tool required for a given Block of Lenses.*" When a new system of lenses has to be worked it is desirable to select the best method of blocking and to make the diameter of the tool equal to the diameter of the complete block. The size of the tool may be determined by calculation or by previous experience, but the author described how this may also be done by making use of any concave tool of known radius.

Then followed a paper on "*A Variable Angle Collimator*," by Mr. T. F. Connolly, M.Sc. The instrument described differs from an ordinary collimator in having a bi-prism introduced between the diaphragm and the object glass. The effect of this is to produce two separate images of the central wire, which images are collimated by the object glass as though they were real wires. The bi-prism is mounted in a short tube sliding within the collimator body, and its position is indicated on the outside of the collimator on a longitudinal scale. A movement of the bi-prism varies the distance between the images as it slides along, and this variable separation of the collimated images provides a convenient means for angular measurement. If the scale is graduated to correspond with angular separation it can be used as a standard of angular measurement for such purposes as marking off or checking stadia intervals on levels or theodolites or for checking the graticules in prism binoculars. If a lens or any optical system forming a real image is introduced into the parallel rays emerging from the collimator, images of the wire are formed; by sliding the bi-prism their distance apart may be made to coincide with two pointers in an observing eyepiece. The position of the bi-prism is a function of the true focal length or true diopters, and the scale may be calibrated to show these. With the experimental instrument results consistent within 0.1 D (one-tenth diopter) have been obtained with powers varying from 2D to 10D. The scale, however, is long enough to allow calibration up to 20D.

This was followed by a paper by Mr. P. F. Everitt, B.Sc., on "*The Design and Testing of Telescope Objectives*," in which the author first describes the four principal aberrations of the telescope objective, proceeding from them to others of less importance, and finally reducing the problem to the fulfilment of three or more of six conditions which it is desirable to satisfy. After referring to the existing tables of approximate solutions, trigonometrical formulæ are given by means of which selected rays are accurately traced through an objective, and the aberration is shown numerically in an example in which the chromatic aberration of an objective is altered at will. A short description of the main types of objectives is given, showing the purposes for which they are best adapted and also some methods of testing, including the Hartmann system. In the conclusion the author states that he had only been able to give a brief outline of the subject, owing to considerations of time and space and expresses the hope that it may induce others to take a greater interest in the mathematical side of the problem.

"DELTA" AS A TRADE NAME.—A motion in behalf of the Delta Metal Company, Limited, of London and Birmingham, against Carl Meier-Mattes and Ulrich Bretscher, trading as C. Meier-Mattes and Co., manufacturers' agents, of London, came before Mr. Justice Sargant in the Chancery Division on March 9. The plaintiffs asked for an injunction "to restrain the defendants, their servants and agents, from in any manner representing or acting so as to be calculated to lead to the belief that they were the agents for, or otherwise connected with, or conducting the business of, the plaintiffs, whether by misstating the name of any foreign company for whom they act, or otherwise. Mr. Sebastian, who appeared for the plaintiffs, said that the parties had agreed to make an end of the matter and to take an order on terms arranged. The plaintiffs were a company who carried on an extensive business in metal goods in this country and abroad. The name "Delta" had been registered as their trade-mark for a long time, and their goods were known as "Delta" goods. There was a company incorporated in Switzerland which a year or two ago changed its name from "Schraubenfabrik Solothurn A.G." into "Delta Company, Schweizerische Praxisionsschrauben-fabrik und Facondrenerei." The fact came to the plaintiffs' notice last year through the defendants issuing an announcement that they were the agents for the Swiss "Delta" Company. The plaintiffs had brought the action in order to restrain the defendants from using anything but the full name of the Swiss company, and upon that basis terms had been agreed. The plaintiffs had evidence that mistakes had been made, owing to the similarity of names, even by Government Departments. The defendants also agreed to deliver up documents bearing the name the plaintiffs objected to, or bearing anything otherwise than the full name of the company. Mr. Baker, who appeared for the defendants, said that they acted in good faith throughout, and they consented to judgment because they had no desire or interest in representing that they were in any way connected with the plaintiffs. His lordship directed the consent order to be made on the terms arranged.

"THE TESTING OF MACHINE TOOLS."

TO THE EDITOR OF ENGINEERING.

SIR,—In the review of my book with the above title which appears in your issue of the 2nd inst. I notice that the reviewer, in discussing that part of the book in which consideration is given to questions relating to machine-tool speed and feed tests, states that formula (23) as given in the book is incorrect. I should like to join issue with the reviewer and say that the formula is quite correct, a fact that can be proved by means of the following analysis.

To fix our ideas we will assume that we have to deal with a machine-tool headstock having one set of double back-gearing working in conjunction with a stepped-cone pulley. Let the pulley be provided with four steps, so that n will be 8. Then if N = the lowest spindle speed in revolutions per minute, and r = the common ratio of successive spindle speeds, we have that the range of spindle speeds is as follows:—

$$N,\ N\,r,\ N\,r^2 \ \ldots\ldots\ N\,r^7.$$

From this it will be seen that the index of r for any speed is the number of the speed less 1. Thus, the fifth speed is $N\,r^4$, and this is the lowest speed obtainable with the back-gearing out of action. Therefore, if R = the ratio of the back-gearing, it follows that—

$$R = \frac{N}{N\,r^4} = \frac{1}{r^4} = \frac{1}{r^{\frac{n}{2}}}.$$

This is the formula which is given in the book.

I shall be glad if you will kindly publish this letter so as to remove any false impression which may have been created by the review.

GEO. W. BURLEY,
Lecturer in Engineering and Theory and Practice of Machine Tools.
Department of Applied Science, St. George's Square, Sheffield, March 9, 1917.

[We regret the error made in the review of Mr. Burley's book. Mr. Burley's letter was forwarded to the author of the review, who writes: "I regret that I did not read the sense of Mr. Burley's remarks correctly, and consequently I invented the mistake in this equation. Mr. Burley's letter now makes the matter clear."—ED. E.]

VULGAR *VERSUS* DECIMAL FRACTIONS.

TO THE EDITOR OF ENGINEERING.

SIR,—Mr. Halsey's writing is so charming as to make one almost believe that the advisability of adopting the metric system and decimal coinage depends on our power of expressing some very simple vulgar fractions in decimals, whereas the question actually hinges on the relative convenience of the proposed and of the existing systems.

Foremost is the educational aspect. A Swiss child learns all the metric weights and measures from casual allusions by the teacher and by reference to a wall diagram, which familiarises him with the fact of there being such things as kilometres, and metres and millimetres. The thousandfold relationship of each of these lengths to the next is learnt by him in a few moments and retained for life. Learning the names demands the same time as learning the word horizon or the name of any other abstract conception, but when he has become familiar with kilometre and millimetre he quickly seizes the meaning of kilogramme and milligramme. Can the same be said of our weights and measures, especially in the United States of America, where they have two kinds of tons and two kinds of gallons?

A peculiar interest attaches, however, to Mr. Halsey's letter, because it shows that our opponents are retiring on a second line of defence and have to assume that we, the decimalists, may not use vulgar fractions, but must confine ourselves to live (arithmetically) on decimals.

Yet we are expected to start all our computations from some decimal equivalent of a vulgar fraction. He gives us the simple fraction $\frac{1}{6}$ and then asks us to struggle with its decimal equivalent 0.1666 +; we might as well ask him to juggle with $\frac{1}{3333}$ + as the equivalent of 0.3.

In real life such things do not occur, because every measurement and every value is an approximation. When an engineer determines on the use of a certain size of bolt, that size is not the exact result of a calculation. It is the next larger size available in his market; and the available sizes will vary according as he is in a metric country or in an "inch-using" country.

The old geography books illustrate this craving for extreme accuracy in translating an approximation. Where Continental geographies gave the height of Mount Everest as 8,850 m., this was duly translated as 29,002 ft. (*vide* "British Encyclopædia").

We find the same peculiarity in translations of scientific books. Where the author gives a speed as varying from "15 to 20 kilometres per hour," it becomes "9⅓ to 12½ miles per hour."

Mr. Halsey gives another puzzle in the shape of 0.140625 as the decimal equivalent of $\frac{1}{8} \times \frac{1}{8}$. Here, again, the decimalist is supposed to obtain his problems from his opponent's measures. Let us suppose that he is an engineer and that his conscience will not allow him to use a vulgar fraction. He wishes to calculate the weight of some square section wire "$\frac{1}{8} \times \frac{1}{8}$." Would he aim at such amazing accuracy as implied? Knowing that the wear of dies involves a variation of 2 per cent. in sectional area, he will be satisfied with 0.14, which is accurate to the extent of $\frac{1}{7}$ per cent. He certainly would not think of 0.140625, with its accuracy of 1 in 140,000.

The basic feature, as Mr. Halsey says, of each system is the reduction, on the one hand, to the lowest denominator and, on the other hand, to a common denominator. For all arithmetical operations the latter is preferable, even in the case of division by 2, 4, 8 or 16, as will be realised by anyone seeking the half or quarter of 481 mm. and its equivalent 1 ft. 7⅓ in.

When it comes to comparisons, the decimals again have the advantage. "Spring" mining shares are quoted one day at 2$\frac{31}{32}$*l.* and the next day at 2$\frac{7}{8}$*l.* Surely it would tend to clearer thinking if they were quoted at 2.853*l.* and 2.875*l.*

In reply to the criticism of the dollar coinage, and its shameless use of 2 as a proportion between coins, it must be confessed that a British decimal coinage will probably have to bear the disgrace of a 4-cent coin.

As to the "minute and obscure" millimetre, it is alarming to think of Mr. Halsey's opinion of the micron and the millimicron and all the science of colloids, which are becoming so important in manufacturing.

Yours truly,
EDWARD C. BURTON.
Royal Societies' Club, St. James's-street, W.,
March 13, 1917.

IMPERIAL PREFERENCE IN TRADE.

TO THE EDITOR OF ENGINEERING.

SIR,—Will "A Student of History" kindly give his authority for "the sequence of events which was followed in Austria," viz., the manufacturers got a home trade for threepenny pencils that enabled them to reduce their working costs and, after a time, to produce a good twopenny pencil?

"A STUDENT OF POLITICAL ECONOMY."
March 11, 1917.

"CUTTING AND CHIPPING OF GLASS."

TO THE EDITOR OF ENGINEERING.

SIR,—As the process of chipping glass by means of the contraction of a film of glue would appear to be of interest, it may be pointed out that there will be found in Spon's "Workshop Receipts," vol. ii, a note on "Glass, Crystalline or Chipped," from which it may be inferred that the process has been in commercial use at a recent date.

The information given is briefly to the effect that the process has been considered a trade secret and brought to considerable perfection in the United States. It is carried out by sand-blasting or otherwise obscuring the surface of the glass, coating with glue, and drying in racks at a temperature of 95 to 100 deg. F. When dry, in, say, 10 to 20 hours, the glued surface of the glass is torn off, with considerable noise, and pieces of the glass may leap 2 or 3 in. into the air.

If a piece of paper be applied to the coating of glue before it is dry, the appearance of the glass, after chipping, will be coarser and have less of the appearance of feathers.

Elegant effects may be obtained by repeating the operation (double chip), and by the use of glass coloured either throughout or on one surface, also by allowing the protective coating used to define the pattern when sand-blasting to remain, so keeping the glue from the portions which it is not desired to chip.

The glue must be good, as if unsuitable glue is used the result may be unsatisfactory.

GEORGE BLAIR, B.Sc., A.M.Inst.C.E.
Old Kilpatrick, March 12, 1917.

THE WASTE OF PAPER.

TO THE EDITOR OF ENGINEERING.

SIR,—Whilst we are told that paper is scarce and men are urgently wanted for the Army and the services connected therewith, and whilst we are unable to get any iron and unable to keep wagons in anything like the ordinary condition of repair, and the Government are requisitioning wagons to go abroad, and the railway companies are declining to assist in the manner that has been usual to assist in repairing, there are some Government officials at 123, Seymour-street, London, N.W., who have nothing better to do than waste paper by sending out a Circular S.C./11435, with directions and drawings, as to the alteration of brake-lever guards, and the grade of iron to be used in wagon couplings and register plate numbers and such-like, none of which can possibly receive any attention at the present time nor as long as present conditions endure.

A SOUTH WALES ENGINEER.
March 14, 1917.

OPENINGS FOR BRITISH ARTICLES IN ITALIAN MARKETS.—The British Chamber of Commerce for Italy, Genoa, has issued lists Nos. 30 and 31, giving brief particulars of possible trade connections with Italy.

CONTRACTS.—Illustrated descriptions of the new central station on the Niagara River, near the Niagara Falls, are given in *Electrical World* and in *Power*. Five marine-type Babcock boilers, each 11,400 sq. ft. heating surface, are working; the furnaces are all double-ended, and have a 15-retort Erith-Riley stoker at each end. The stokers are worked at very easy duty, assuring the most economical combustion; they are grateless, archless, and continuous cleaning. Ten more 15-retort Erith-Riley stokers have since been ordered, making 20 stokers, each 24 ft. wide, on 10 double-ended boilers, for 120,000 kw. In another large central station the latest extension consists of 12 single-ended boilers, each 13,600 sq. ft. heating surface; each has the same 15-retort Erith-Riley stoker, one for each of the 12 large boilers. The Yorkshire Electric Power Company has just ordered two 9-retort stokers for two 30,000-lb. boilers. The makers are Erith's Engineering Company, Limited, 70, Gracechurch-street, London.

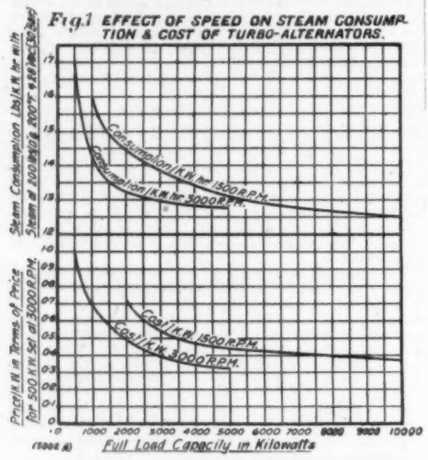
STEAM TURBINES FOR LAND PURPOSES.*

By H. L. GUY, A.M.I.Mech.E., Assoc.M.Inst.C.E., Manchester.

SOME four or five years have passed since a paper on this subject was brought before your notice. It is the intention of the author to consider some of the developments which have matured in the interval. The broad lines can be gauged by considering the difference in the production of the turbine department of the firm with which the author is associated during the period under review, confining attention to machines over 200 k.w. capacity.

The total output in kilowatts for 1915 was more than double that for 1910. The reasons for these changes in the relative importance of the various types of machines are readily found. It has now been established that a pure high-pressure turbine is more efficient than a combination of a reciprocating engine exhausting into a low-pressure or mixed-pressure turbine, with the result that high-pressure turbines are being installed where the former types were adopted a few years ago. This represents a distinct advance in the art of turbine construction, because it was still maintained at the earlier date, and with some justification, that the reciprocating low-pressure turbine combination represented the ideal.

Fig. 1. EFFECT OF SPEED ON STEAM CONSUMPTION & COST OF TURBO-ALTERNATORS.


Steam Consumption Lbs/K.W. hr with Steam at 200 lbs/sq. INCH & 60 Deg. Superheat
Consumption K.W. hr 1500 R.P.M.
Consumption K.W. hr 3000 R.P.M.
Profit K.W. in Terms of Price for 500 K.W. Set at 3000 R.P.M.
Cost K.W. 1500 R.P.M.
Cost K.W. 3000 R.P.M.
Full Load Capacity in Kilowatts

Another factor which in many cases operated to ensure the installation of a high-pressure rather than a mixed-pressure or low-pressure turbine lies in the fact that it is often a doubtful expedient to couple a new turbine of the latter class to an obsolete or more or less worn-out engine, which would in any case be scrapped long before the useful life of the turbine has expired.

There are, of course, certain types of modern plant at present driven by reciprocating engines which must be of the non-condensing type, such as rolling mill or winding engines, and until these machines are electrically driven there will be a suitable field for mixed-pressure turbines in entirely new installations.

The significance of the absence of large back-pressure turbines in 1915 lies in the appearance of the reducing turbines in the latter year, which, by virtue of their greater flexibility, with very few exceptions have valuable advantages over the former type.

One other characteristic of the change in the turbines produced in these two years is shown in the following table :—

Date.	Per Cent. of Number of Machines Built.		Average Output of Each Machine.	
	3,000 r.p.m.	1,500 r.p.m.	3,000 r.p.m.	1,500 r.p.m.
1910	46.8	19.2	588	2,800
1915	76.0	15.2	1,810	5,300

Fig. 2. EFFECT OF SPEED ON SIZE OF TURBO-ALTERNATORS.

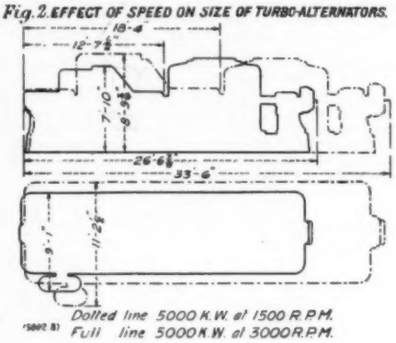


Fig. 3. STRESSES IN LAST ROW OF TURBINE BLADES.

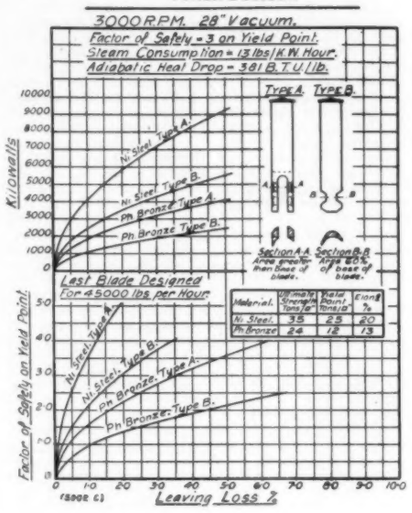
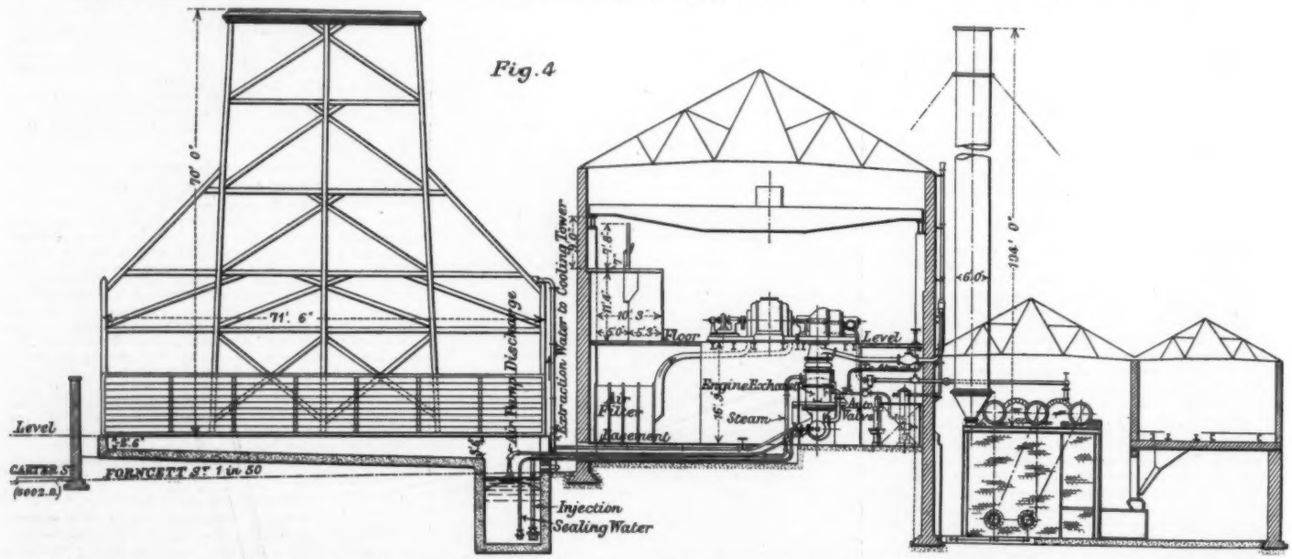

3000 R.P.M. 28" Vacuum.
Factor of Safety = 3 on Yield Point.
Steam Consumption = 13 lbs. / K.W. Hour.
Adiabatic Heat Drop = 301 B.T.U. / lb.
Kilowatts
TYPE A.
TYPE B.
Ni Steel Type A.
Ni Steel Type B.
Ph Bronze Type A.
Ph Bronze Type B.
Section A-A Area greater than base of blade.
Section B-B Area 60% of base of blade.
Last Blade Designed For 45000 lbs. per Hour.
Material. | Ultimate Strength Tons / in² | Yield Point Tons / in² | Elong. %
Ni. Steel: 35 25 20
Ph. Bronze 24 12 13
Factor of Safety on Yield Point.
Leaving Loss %

Fig. 4



Date.	Per Cent. of Number of Turbines Built.					Per Cent. of Total Full-Load Capacity.					Average Capacity, Kilowatts.
	High Pressure.	Mixed Pressure.	Low Pressure.	Back Pressure.	Reducing Pressure.	High Pressure.	Mixed Pressure.	Low Pressure.	Back Pressure.	Reducing Pressure.	
1910	42.5	38.5	6.5	10.5	—	74.0	20.6	3.5	1.9	—	1,550
1915	71.3	13.6	1.5	—	13.6	83.3	7.52	0.18	—	9	2,300

* Paper read before the Manchester Association of Engineers, on January 27, 1917.

The continuous tendency towards increased outputs at high speeds exhibited by these figures is responsible for many of the changes in design which have taken place. The object of this development is revealed by the curves shown in Fig. 1, where the upper two curves show the steam consumption obtained for the steam conditions stated, with turbo-generator sets of various outputs at 3,000 and 1,500 r.p.m., while the lower curves show the variation in cost per kilowatt of turbo-generator sets at these two speeds.

It will be seen that at 3,000 kw. the steam consumption with a 3,000-r.p.m. set is 6.15 per cent. better than at 1,500 r.p.m., while the cost per kilowatt is 27.8 per cent. lower. For a 5,000 kw. set the steam consumption at 3,000 r.p.m. is 2.67 per cent. better than at 1,500 r.p.m., and the cost per kilowatt 26.2 per cent. lower. The curves shown give safe values of the present steam consumption and cost ratios, but it should be remembered that as the number of frames available is not unlimited, these curves should really be stepped lines, and that as various values are set on steam consumption by different purchasers, a manufacturer may use several frames for the same output, which results in different steam consumption, and therefore price per kilowatt, being given. The relative sizes of a 5,000-kw. set at 3,000 r.p.m. and at 1,500 is illustrated in Fig. 2.

The way in which increasing the output at high speeds reacts on design can be illustrated by considering the effect upon various types of blading. The output which can safely be obtained at a given speed and vacuum is limited largely by the effect upon the last row of blades. If the safe length of blades be fixed, the volume of steam which can be passed through the last row can only be increased, and with it the output of the machine at a given vacuum, by increasing the velocity of the steam through the blades.

Now the kinetic energy of the steam leaving the last row of blades passes straight into the exhaust, and represents a dead loss in efficiency. This is called the "leaving loss," and must be kept small if a reasonable turbine efficiency is to be obtained. On the other hand if the leaving loss be reduced by increasing the blade length, the factor of safety in the blade must be sacrificed In Fig. 3 the leaving loss has been plotted for two types of blade fastenings, and two standard blade materials, against the corresponding output of the turbine, assuming a factor of safety in the complete blade is to be 3 on the elastic limit. This factor of safety has been chosen as reasonable, and is justified by an extensive experience.

Suppose we fix on a leaving loss of 1½ per cent. as being a proper value, then with nickel steel blading a turbine of 5,000 kw. output can be built, having a forked blade, or 3,000 kw. with a dovetail blade ; with phosphor bronze the maximum output is 2,250 kw. for a forked blade and 1,350 kw. for a dovetail blade. If the turbine having nickel steel dovetail blades is rated at 5,000 kw., the leaving loss, and therefore the steam consumption, will be 2.7 per cent. greater than with forked blades having the same factor of safety of 3 on the elastic limit. The curve also shows that phosphor bronze is inadmissible for outputs greater than 3,000 kw., even when

STEAM TURBINES FOR LAND PURPOSES.

Fig. 6.

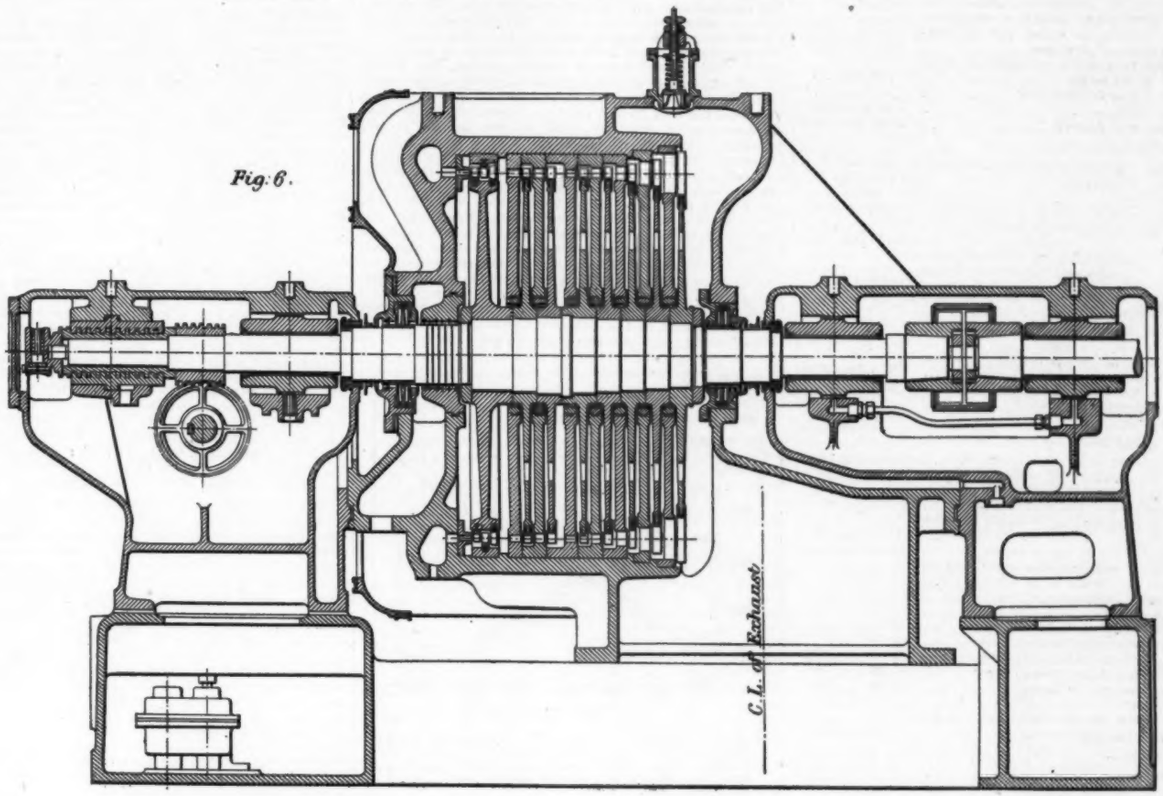
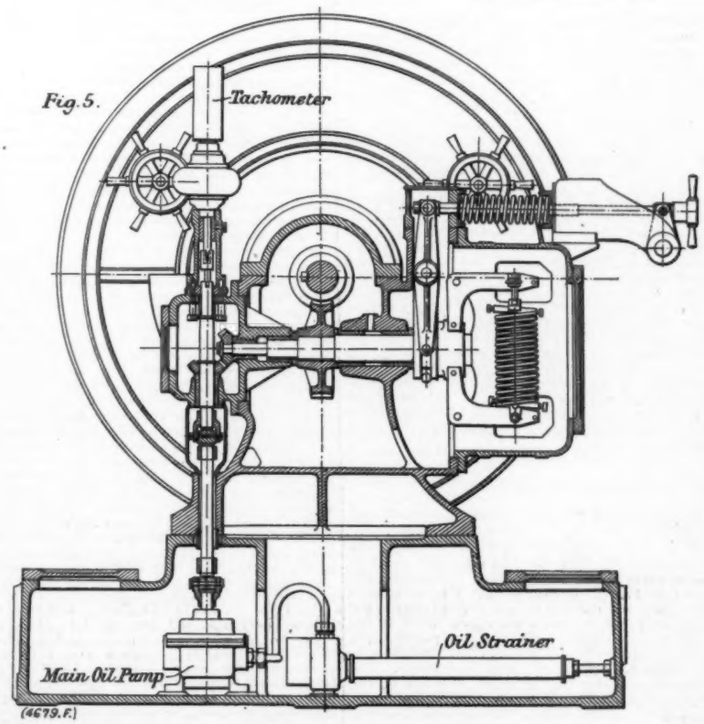


Fig. 5.



(4679.F.)

forked blades are used. For mixed-pressure and low-pressure turbines the output given should be reduced by one-half. For vacua other than 28 in. the leaving loss varies as the square of the specific volume of the steam leaving the last row, so that the output for a given leaving loss approximately varies inversely as the square of the absolute pressure. The output which can be obtained with a given factor of safety and leaving loss varies directly as the strength of the material used for the blades, and is independent of their mean diameter.

The same results are exhibited in another way in the lower half of Fig. 3, which shows that with a leaving loss of 1½ per cent. the factor of safety on the elastic limit will be 4.5 for nickel steel forked blades, or 1.2 for bronze dovetail blades.

The present position of high-pressure turbines can perhaps be most readily appreciated by considering certain typical installations. Fig. 4 shows the lay-out of a typical industrial power station. The plant in the first instance consisted of the following :—

Turbine.—2,000-kw., 3,000-r.p.m., British Westinghouse Rateau impulse type.

Steam Conditions.—160 lb. per square inch gauge, 160 deg. F. superheat, 28 in. vacuum.

Generator.—Fifty-cycle, three-phase, 6,600 volts.

Condensing Plant.—Le Blanc multiple-jet type, to condense 28,700 lb. of steam per hour when supplied with 2,200 gallons per minute of water at 75 deg. F., pumps engine-driven.

Cooling Tower.—Balcke type, reduced 143,000 gallons water per hour from 98 deg. F. to 75 deg. F., with air temperature of 60 deg. F., humidity 75 per cent., area at base of tower 2,220 sq. ft., height of tower, 80 ft.

Boiler.—Stirling type, 33,000 lb. per hour capacity, 8,900 sq. ft. heating surface, drop-link stokers, 96 sq. ft. grate area, no economiser.

Feed Heater.—Holden and Brook type, into which the condenser pump engine and Weir feed pumps exhaust.

Sections through the turbine are shown at Figs. 5 and 6. The rotor consists of a two-row velocity wheel, followed by seven Rateau wheels, the first blade being $\frac{13}{16}$ in. high, and the last $6\frac{7}{8}$ in. These wheels rotate in the cells, into which the cylinder is divided by the diaphragms. In the first set of nozzles the steam is admitted over part of the total circumference only. The arc of admission is increased in the first two diaphragms, while the steam is admitted around the whole circumference of the last five diaphragms. A thrust block is provided to preserve the relative position of the rotor and stator. The blading is milled from the solid, that on the velocity wheel being attached by T roots, while that on the Rateau stages is attached by a forked root, each blade being retained by two rivets. The clearances at the blades are not less than ¼ in. axially, or ½ in radially.

Six months after the plant was first started up a 24-hour test was made under ordinary working conditions, the plant being worked by the station staff, the turbine taking the works load, which was of the variable nature usual in a heavy steel works. The variable nature of the steam conditions and the load is shown in Fig. 7, page 248. The following results were obtained :—

SUMMARY OF RESULTS.

Date of Test, March 15 and 16, 1916. Duration of Test, 24 hours.

Boiler-house—

Total weight of coal burnt	76,776 lb.
,, ,, ash	3,304 lb.
,, ,, ash, divided total weight of coal ...	4.3 per cent.
Average calorific value of coal (lower value)	13,724 B.T.U. per lb.
,, moisture in coal	2.391 per cent.
,, ash by sample	4.36 per cent.
Total feed water metered	641,000 lb.

SUMMARY OF RESULTS.—*continued.*

Total town water metered	471,000 lb.
,, ,, ,, divide total feed water = make-up water for all purposes	73.5 per cent.
Average feed water temperature after heaters	158 deg. F.
,, flue temperature	486 deg. F.
,, CO_2	8.82 per cent.
Efficiency of boilers	69.83 per cent.
Condensing Plant—	
Average injection water temperature	68 deg. F.
,, extraction	87.5 deg. F.
Water ratio	50 to 1
,, injection quantity (average) ...	2,230 g.p.m.
Average vacuum temperature ...	99.6 deg. F.
,, ,, efficiency	96.16 per cent.
,, difference in vacuum temperature and extraction water temperature	12.1 deg. F.
Engine-room—	
Average steam pressure before stop valve ... ...157 lb. per sq.in. g.	
,, ,, temperature before stop valve ...	510 deg. F.
,, vacuum (30-in. barometer) ...	28.1 in. Hg.
Total kilowatts metered	36,570
Load factor	76.4 per cent.
Cooling Tower—	
Temperature of air near tower ...	40 deg. F.
Inlet temperature of water at top of tower	91.75 deg. F.
Temperature of water in sump ...	70 deg. F.
Drop in temperature of water through tower	21.75 deg. F.
Velocity of air at top of trays... ...	188 ft. per min.
Wet bulb thermometer over top of trays	77.5 deg. F.
Dry bulb thermometer over top of trays	78.8 deg. F.
Humidity top of trays	93.4 per cent.
Wet bulb temperature near tower ...	37.96 deg. F.
Dry bulb temperature near tower ...	39.43 deg. F.
Relative humidity near tower ...	88.26 per cent.
Cooling water over tower	2,200 g.p.m.
Barometer	29.68 in.
Water taken up per cubic foot of air passing through tower	7.26 grains
Results—	
Coal per kilowatt-hour	2.1 lb.
Steam per pound of coal	8.35 lb.
Feed-water metered for all purposes per kilowatt-hour...	17.52

The vacuum efficiency of 96.16 per cent. pointed to an air leakage, which was found later and stopped, with the result that the efficiency was improved to 98 per cent. The feed water metered includes that required for the main turbine, the auxiliary engines, feed pumps, leakages, drains, and the steam lost during the 53½ minutes that the boilers were blowing-off.

In January, 1915, a 3,000-kw., 3,000-r.p.m. set supplied to the Charing Cross, West End and City Electricity Supply Company, Limited, was started up, and is illustrated in Fig. 8, page 248. The plant consists of :—

Turbine.—3,000-kw., 3,000-r.p.m. Rateau impulse type, containing 11 Rateau stages.

Steam Conditions.—170 lb. per square inch gauge, 55 deg. F. superheat, 27½ in. vacuum.

Generator.—Fifty cycles, three-phase, 10,000 volts.

Condensing Plant.—Surface type.

This was one of the first sets of this speed and rating running in this country. The auxiliary turbine was designed for 220 brake horse-power at 2,500 r.p.m., rather a high output for such a set, resulting from the fact that the cooling water was pumped over a high cooling tower, and that both the circulating pump and air pump were large, because the condenser, in addition to dealing with the steam from the main turbine, was required to condense the exhaust steam from the two Bellis and Morcom engine sets shown in the background of Fig. 8.

The guarantees included the steam required for the auxiliary turbine, which exhausted into the main turbine at a stage where the pressure was atmospheric at full load. The official test results corrected to guarantee conditions were as follow :—

Load	Over-Load.	Full.	Three-Quarter.	Half.
Test result, lb. per kw.-hr.	15.9	15.9	16.7	19.13

A 5,000-kw. set at 3,000 r.p.m., installed in the Stuart-street Power Station of the Manchester Corporation, was started up in October, 1915, and described by Mr. S. L. Pearce, in his lecture before this association, on November 20, 1915. Between November 22, 1915, and November 13, 1916, this set generated 22,293,400 kw.-hours, or 49.4 per cent. of that possible if it had been on full load for the whole of the time between those dates. The two last turbines differ from the first described in that the first stage consists of a wheel having one row of blades in place of the two-stage velocity wheel, a feature which provides a second illustration of the effects of high speeds on design.

The success of impulse turbines has been in a large measure due to the fact that the pressure and temperature inside the turbine casing is kept low by allowing a much larger expansion in the first than in succeeding stages, with the result that the full boiler steam pressure and temperature is confined to the steam chest and nozzle boxes, which are small chambers, and can when necessary be made of cast steel at a reasonable cost. In turbines whose blades rotate at a slow or moderate peripheral speed the steam velocity resulting from this large initial expansion can be utilised most efficiently in a velocity wheel having two rows of moving blades, but with a given expansion as the peripheral speed of the blade increases the work done in the second row decreases, whereas the friction and windage losses increase as some power greater than the cube of the speed. It will therefore be readily understood that a point will be reached when the second row of blades does not perform enough work to rotate it at the required speed, the deficit being made up by the first row. This effect is illustrated by Fig. 9, page 248. It will be seen that with the conditions stated, and with blades having 30 in. mean diameter, the addition of the second row increases the stage efficiency by 25 per cent., but that if the mean diameter is 47 in. the second row makes no contribution to the work done in the first stage, so it can be dropped with advantage.

A 6,000-kw., 1,500-r.p.m. set, installed at the Port Dundas station of the Glasgow Corporation, illustrates the reliability of a modern steam turbine unit and of the

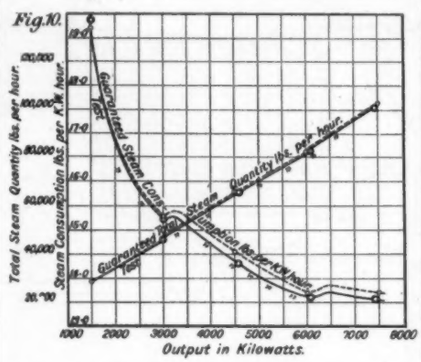


FIG. 10. 6,000-kw. High-Pressure Westinghouse Rateau turbine, 1,500 r.p.m., official test curve. Guarantee conditions :—high-pressure steam ; pressure, 190 lb. sq. in. g. ; superheat, 166 deg. F. ; vacuum at full load, 27·45 in. ; barometer, 33 in.

importance of coal consumption. The turbine is of the Rateau impulse type, designed for 190 lb. per square inch gauge and 166 deg. F. superheat, containing a velocity wheel followed by 10 Rateau impulse stages ; the maximum tip speed being 553 ft. per second. It is coupled to a three-phase 50 per 6,600-volt generator. A condenser having a surface of 12,800 sq. ft., or 2.13 sq. ft. per kilowatt at normal rating, maintains a vacuum of 27.45 in., at 30 in. barometer, when supplied with 9,875 gallons of cooling water per minute at a temperature of 85 deg. F. The official test results are plotted in Fig. 10.

Between the dates of July 24, 1914, and October 31, 1915, this set generated 52,852,500 units, or 78.93 per cent. of the power which could have been generated if it had been carrying full load for the whole time. The set was started up in February, 1914, and had generated 100,000,000 units by August, 1916, so that with a coal consumption of, say, 1.75 lb. per kilowatt-hour, the coal used by the set would equal 78,250 tons in 2¼ years, or at the rate of 31,300 tons per annum, which represents a coal bill of 23,500*l.* per annum with coal at 15*s.* per ton, so that each 1 lb. improvement in steam consumption saves about 1,710*l.* per annum in cost of fuel alone. In the example stated, if the saving in coal consumption alone is considered and capitalised at the rate of 10 per cent., an increase in purchase price of 2,350*l.* would be justified for each 1 per cent. improvement in steam consumption.

(To be continued.)

THE PENNSYLVANIA RAILROAD SYSTEM.—The Pennsylvania Railroad System has issued, in booklet form, a historical and descriptive treatise covering the territory traversed by its lines. The principal object of the booklet is to point out the most interesting and picturesque incidents connected with the settlement and subsequent development of this region, which has become the richest and most thickly populated in the United States ; also to set forth the present character of the various portions of the territory with reference to industry, mining, agriculture and commerce. The region covered includes the principal sections of the Middle States and the Central West, together with some portions of the Southern States. A brief description is given of all the cities and of the more important towns on the Pennsylvania Railroad, east and west of Pittsburg, with the business advantages and achievements of each, together with a number of historical incidents which relate chiefly to events in the discovery period of American history, to happenings during colonial days, the Revolution, the War of 1812, the wars with Mexico and the Indians, and the Civil War. The book is profusely illustrated, and is accompanied by a large folding map of the territory served by the Pennsylvania system.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

South Yorkshire Coal Trade.—The position has not undergone any material alteration. Collieries and dealers are anxiously anticipating the end of the present month, for with the passing of March more congenial weather can be confidently expected, with a consequent diminution in the demand for heating purposes. In the house coal section this will make a pronounced difference. At present depots and merchants have many arrears on their books, chiefly as a result of the periodical severe wintry spells. The irregularity and insufficiency of supplies make it impossible for these to be cleared off, even with the demand at the ordinary winter level. Manufacturers are also expected to require less fuel for heating purposes in the spring season, but this will not greatly affect the situation, being more than counterbalanced by the increased and pressing requirements for direct power work. There is still a shortage of the smaller sorts, but with a good tonnage of large steam coal to hand, works are able to keep running. Railways are also receiving large quantities. Inland gas works are finding it a difficult matter to get all they contracted for, but the position is expected to become much easier in the course of a few weeks. Coke maintains a strong tone, and top prices are paid. Little interest centres in the export trade, which is now principally with Allied Powers. Quotations :—Best branch hand-picked, 20*s.* 6*d.* to 21*s.* 6*d.* ; Barnsley best Silkstone, 18*s.* 6*d.* to 19*s.* 6*d.* ; Derbyshire best brights, 18*s.* 6*d.* to 19*s.* 6*d.* ; Derbyshire house coal, 17*s.* to 18*s.* ; best large nuts, 16*s.* 6*d.* to 17*s.* 6*d.* ; small nuts, 15*s.* 6*d.* to 16*s.* 6*d.* ; Yorkshire hards, 16*s.* 6*d.* to 17*s.* 6*d.* ; Derbyshire hards, 16*s.* to 17*s.* ; best slacks, 12*s.* to 13*s.* ; seconds, 10*s.* 6*d.* to 11*s.* 6*d.* ; smalls, 7*s.* 6*d.* to 8*s.* 6*d.* per ton at the pit.

Iron and Steel.—The sole topic at the moment seems to be the absorbing one of output. All energies and enterprises are being directed to increasing, as far as possible, the amount of production week by week, and a friendly rivalry exists among the different firms. The greatest call of the moment comes from the shipbuilding yards. These are dependent upon Sheffield for many vital supplies, including the better-known ones of steel plates and tools. The "speeding-up" in the shipbuilding yards has led to a corresponding acceleration of output in the large Sheffield steel works which supply them, particularly the ones which are so closely related to the firms at Belfast, Clydebank and the Tyne. Special steps have been taken to produce the essential material with as little interference as possible. In the demand for tools of all descriptions, and particularly the larger sorts, there has been an enormous increase, and manufacturers are to-day turning out more than double the quantity they did twelve months ago. Though working to the full extent of their capacity, the different works are unable to meet all requirements, and vast quantities of high-speed varieties are wanted in addition to the current output. It will be a big accession of strength when the new works get into complete running order. We were informed this week by Mr. John Harper, the manager of Messrs. Arthur Balfour and Co.'s Broughton-lane branch, that early next month the extension scheme will be completed and the works will then produce 100,000 tools of all sizes per month, as against 35,000 to-day. Other extensions are also making headway, and it is confidently anticipated that in a few weeks' time supply and demand will be much more equalised than they are to-day. Activity prevails in the production of high-speed steel, with the consequence that firms are not hesitating to increase their electric melting plant. It is a surprising thing to note how greatly electric furnaces have found increased popularity in Sheffield during the past twelve months. For the melting of high-speed and the lighter mechanical steel an electric furnace is considered to be unrivalled—a great change from the none-too-remote day when manufacturers looked askance upon such furnaces. File and saw makers have more work on hand than they can deal with, and, unfortunately, arrears are inevitable, despite the importance of the goods. Hack saws are constantly wanted by the War Office, the Admiralty and our Allies. Tramway work continues good, and the firms on rolling-stock of all classes find a superabundance of orders. The metal market does not possess any unusual feature, for the general tightness and firmness in all departments have become quite a common characteristic, and show no present signs of disappearing. In all brands of common irons there is heavy buying, whilst steel billets are only obtainable for war work. Agricultural engineers have a boom on hand, but find the pressure of countless orders exasperating. They could utilise the services of as many more grinders as they have engaged if these were available. As it is, the Army has swallowed them up. Cutlery, silver and plate firms continue to receive big indents, but plate manufacturers are too much perturbed about copper supplies to view the future with equanimity. The state of the general foreign and colonial trade gives cause for satisfaction.

Sheffield Gas Light Company, Limited.—The large firms which depend upon the gas supply for much of their power and lighting would be interested in the statement made at the annual meeting of the Sheffield Gas Light Company, Limited, on Monday, by the chairman, Mr. Wilson Mappin. He remarked that the Daylight Saving Bill decreased the gas consumption in the city last year by 59,432,000 cub. ft. and saved householders a sum of 5,200*l.* The darkening of the streets reduced the receipts from this source from 9,000*l.* of an annual average in preceding years to 988*l.* The chairman added that so badly hit were they through the labour shortage that retorts, after being heated, had had to stand idle for weeks waiting for men to charge them. The office and other officials had come to the company's

assistance by voluntarily undertaking coke-loading and other duties at week-ends. There was a profit on the year's working of 110,048*l.* 1*s.*, and a dividend at the rate of 10 per cent. was declared.

Sheffield Trade Matters.—The directors of Messrs. Robert Hadfields, Limited, met at the East Hecla Works, Sheffield, on Monday, and decided to recommend that, in addition to the interim dividend of 1*s.* per share paid in July last on the ordinary shares, a further dividend be paid on the ordinary shares of 4*s.* per share, making the rate the same as last year, together with a bonus of 1*s.* per share, all free of tax. The distribution for the full year, therefore, comes to 30 per cent., which is the highest for some time past. In 1915 the rate was 25 per cent.; 1914, 22½ per cent.; and 1912 and 1913, 20 per cent.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scotch Steel Trade.—Work in the steelmaking establishments goes on as usual, the only difference, perhaps, being an endeavour to add to the ceaseless activity prevailing everywhere. Without doubt the success of the British Army in the Eastern zone of war will have the effect of further stimulating those upon whom falls the onus of providing the requisite material for the use both of Army and Navy; yet it is problematic whether it will be possible to augment the heavy output to any appreciable extent. Every available rolling mill is in full operation and more than likely to continue so for some considerable time ahead. There is no cessation of the Government's demands for shell-making steel, both bars and billets, nor for plates and steel material of all descriptions required for shipbuilding purposes, both for mercantile and Admiralty contracts. With the exception of some small lots being shipped to Allied countries, export is practically at a standstill and prices purely nominal and much on the lines of last week. The home rates, being officially fixed, remain unaltered.

Malleable Iron Trade.—The comparative scarcity of iron in the malleable iron works is being distinctly felt alike through the excessive demand and the increased production of steel in the steel departments. Some considerable export business is being put through, both in iron and steel, but naturally the home demands are of the first importance, the requirements of Government alone being practically sufficient to keep every mill going. Prices, of course, remain firm, and "Crown" bars are quoted about 15*l.* per ton.

Scotch Pig-Iron Trade. — While the briskness which characterises the pig-iron trade at the present time is as strong as ever, no new developments fall to be recorded over the week. The demand for hematite continues to be specially strong, the entire output being so rapidly absorbed by the local steel works that makers are constantly pressed for delivery, and this notwithstanding the fact that the number of furnaces in full blast has been considerably augmented during the past few weeks. It is thus practically impossible to obtain any hematite for other than war purposes. Foundry and forge grades are also much in request, foundry being a trifle firmer for export, although the home prices, being fixed, remain as formerly. Considering the difficulties with which makers have meantime to contend, it is astonishing that everything is working so very smoothly.

Shipyard Extension at Leith.—Messrs. Hawthorns, shipbuilders, Leith, have just intimated to the members of the Leith Dock Commission—from whom they lease their Victoria shipyard—that they contemplate making some rather extensive improvements there for the purpose of increasing the output of new tonnage. It is the firm's intention so to extend the yard that there will be three building berths, each one of which will be capable of taking vessels of from 200 ft. to 320 ft. in length. The proposed development was submitted to a meeting of the Commission, and then remitted to the Properties Committee with powers.

To Improve Puddling.—In connection with the scheme which has just been set on foot for the purpose of improving the methods of puddling and of stimulating the output of iron in the various producing centres of the country, Mr. Walter Dixon, 38, Bath-street, Glasgow, has just been appointed secretary for the local committee appointed by the British Ironmasters' Association to deal with the question. Workmen and others interested in the subject are being asked to submit for approval any original ideas or suggestions which they think will be of material benefit, and arrangements are being made to give suitable awards for any which may be adopted.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—There is no scarcity of pig-iron, and with the March allocations of Cleveland kinds on a very liberal scale for home use and for consumption north of the Tweed, customers are assured of full supplies during the present month. Prompt home business is rather quiet, consumers having purchased sufficient iron to satisfy their early needs, but there is still a very considerable forward trade passing, subject, of course, to any official changes in quotations. On behalf of consumers in Scotland contracts are being made for delivering to the end of June. A rumour prevails that two hematite furnaces are to be transferred to the production of Cleveland pig. Such a change would be hardly welcome, as the supply of Cleveland is ample to meet all home needs and leave a fairly large margin for export; whilst any curtailment of make of hematite would doubtless cause very considerable inconvenience. Shipments of Cleveland pig to our Allies is on a fairly large and growing scale, but there is still room for considerable improvement, the tonnage situation continuing to give trouble. For home use No. 3 Cleveland pig, No. 4 foundry and No. 4 forge all stand at 87*s.* 6*d.*, and No. 1 is 91*s.* 6*d.*; whilst for shipment to our Allies No. 3 is 97*s.* 6*d.* and upward, No. 4 foundry, 96*s.* 6*d.*; No. 4 forge, 95*s.* 6*d.*; and No. 1, 102*s.* 6*d.*; and for export to neutral countries the minimum quotations are 105*s.* for No. 3 and 110*s.* for No. 1.

Hematite Iron.—Only fairly satisfactory accounts are given of the East Coast hematite branch of the iron trade. Values are fully maintained. Nos. 1, 2 and 3 are 122*s.* 6*d.* for home use, 137*s.* 6*d.* for shipment to France, and 142*s.* 6*d.* for export to Italy.

Shipments of Pig-Iron.—Under the conditions prevailing shipments of pig-iron must be regarded as satisfactory. For the first half of the month the loadings at Middlesbrough exceed 20,000 tons, and are quite equal to the clearances to the same date in February; whilst they compare not unfavourably with the close upon 25,000 tons despatched in the first half of March last year.

Coke.—There is an abundant supply of coke, but the heavy demand for local consumption keeps the descriptions needed at the fixed maximum prices that have ruled for some time past. Thus average blast-furnace kinds are 28*s.* at the ovens, and up to 30*s.* 6*d.* at the ovens is named for qualities low in phosphorus.

Foreign Ore.—There is more business passing in foreign ore, and especially in outside kinds. Fairly large quantities are coming to hand. Unloadings at the port of Middlesbrough so far this month reach 63,287 tons.

Manufactured Iron and Steel.—Producers of finished iron and steel are very busily employed, and are still steadily adding to the output by extending works and laying down new plant. The output of mercantile shipbuilding material is increasing in a way that affords much gratification. Prices all round are very strong. The following are among the principal market quotations to home customers:—Common iron bars, 13*l.* 15*s.*; best bars, 14*l.* 2*s.* 6*d.*; double best bars, 14*l.* 10*s.*; treble best bars, 14*l.* 17*s.* 6*d.*; iron ship plates, 13*l.* 10*s.* to 14*l.* 10*s.*; iron ship angles, 13*l.* 15*s.*; iron ship rivets, 17*l.* 10*s.* to 18*l.* 10*s.*; packing iron and steel (parallel), 13*l.*; packing iron and steel (tapered), 15*l.*; steel bars (no test), 14*l.* 10*s.*; steel ship plates, 11*l.* 10*s.*; steel ship angles, 11*l.* 2*s.* 6*d.*; steel ship rivets, 19*l.* to 20*l.*; steel boiler plates, 12*l.* 10*s.*; steel joists, 11*l.* 2*s.* 6*d.*; steel strip, 17*l.*; steel hoops, 17*l.* 10*s.*; and heavy sections of steel rails, 10*l.* 17*s.* 6*d.*

NOTES FROM THE SOUTH-WEST.

Coalfield Situation.—During the past week the irregularity of work at the collieries has become more accentuated. Consequent upon shortage of wagons, arising primarily out of the lack of tonnage, collieries have been rendered idle throughout the coalfield. This is particularly so in the anthracite and western portion of the coalfield. The South Wales Miners' Federation has had a return made of stoppages during February. This return shows a general dislocation of trade, but in the particular area indicated—the anthracite and the contiguous parts of the coalfield—the irregularity of work has become so acute as to result in actual distress. In these circumstances appeals are being made on behalf of the men affected to the Federation for financial assistance from the out-of-work fund. The situation was considered at a meeting of the Executive Council of the Welsh Miners' Federation on Tuesday, when it was decided to grant a donation to relieve the distress, and to approach the Board of Trade with the view of seeing what can be done to provide an equitable distribution of tonnage. As at least a partially remedial measure, energetic action is being taken with the view of securing home-grown timber for pitwood purposes. The new Monmouthshire and South Wales Pitwood Association, which, as already reported, is composed of the associated colliery companies, has already completed negotiations for the purchase of local woods. The necessary implements are being acquired, and in order to secure labour posters have been posted up at the collieries appealing for volunteers to undertake the work of cutting and transporting the timber. The men employed will be paid at the rate of not less than 7*s.* 6*d.* a day, with subsistence allowance and other incidental expenses incurred through having to be working away from their homes. As a matter of pure speculation the project is not regarded as very alluring. As in everything else, there is an art in the felling of timbers, and, therefore, it is not expected that colliery workers will be able to show the same dexterity or the same results as experienced woodcutters. The scheme, however, is not viewed from the standpoint of profit-making, but has been launched with the object of obtaining supplies of the now precious pitwood at all costs. This object, it is believed, will be attained, at any rate to a very appreciable extent, by making the pits less dependent upon overseas supplies.

The Iron and Steel Trades.—In the iron and steel trades work is very brisk, principally on Government account, and there is a general shortage of labour. Many workmen previously employed at the local tinplate works have, however, transferred their services to the steel works, and these to some extent make up for the shortage. The reason for the transference is the depression in the tinplate trade, which has suffered very greatly since the war—principally through the difficulty of obtaining the requisite amount of raw material. The Government have the first claim on all scrap steel, and thus the tinplate trade has been "starved." In the Pontardulais district, however, the mills are still kept going, though in other districts the position is not quite so favourable. Unfortunately there is very little prospect of material improvement during the war, for the reason already stated.

The Coal Market.—Conditions remain unchanged, the chief characteristics being idleness and depression, with prices very weak. The shipping position is entirely responsible for this state of affairs. The authorities usually keep collieries producing the best quality coals regularly employed, but others are obliged to work on hand-to-mouth lines. Second Admiralty, Black Vein and Western Valley large coals are all round 24*s.*, with the inquiry slow. Eastern Valleys are quoted from 21*s.* to 23*s.* Small coals are abundant, and best bunker sorts command no more than 15*s.* 6*d.*, seconds 15*s.*, good cargo sorts 12*s.* 6*d.*, and inferior cargo qualities from 7*s.*, and for spot loading slight concessions can be secured on these figures. Patent fuel for export is also in excessive supply and obtainable from 27*s.* 6*d.*, and foundry coke ranges from 52*s.* 6*d.* to 55*s.* Pitwood remains inadequate to meet requirements despite the arrival of a recent cargo of 8,400 loads, and prices are firm at 75*s.*

Limitation Freights Abandoned for Neutrals.—The Shipping Controller, in a telegram to the chairman of the Cardiff Institute of Shipbrokers, intimates that the Inter-Allied Chartering Committee in London is not bound to the old scheme of limitation freights, so far as neutral tonnage is concerned. This, in effect, means an abandonment of the scheme for this tonnage. A local broker has asked what rate the Inter-Allied Committee were prepared to pay for the near French ports to a neutral steamer, and has been refused above the schedule rate. Open-market chartering is now forbidden, and all free tonnage has to be submitted to the Cardiff Local Committee, who forward particulars to the Inter-Allied Committee.

Finance.—North's Navigation Collieries (1889), Limited, made a profit in 1916, after provision for excess profits duty, &c., of 160,456*l.*, against 130,071*l.* in 1915, and declared a dividend of 20 per cent., against 12½ per cent. The United National Collieries, Limited, made a profit in 1916, after making provision for excess profits duty and placing 100,000*l.* to reserve, of 220,221*l.*, against 299,521*l.* in 1915, and declared a dividend making 25 per cent. for the year, which is the same as in 1915.—The Bedwas Navigation Colliery Company, Limited, made a profit in 1916, after paying debenture interest and providing for income-tax, excess profits duty and contingencies, of 37,077*l.*, against 35,983*l.* in 1915, and declared a dividend, making 12½ per cent. for the year, against nil in 1915.

CONDENSERS.—The Mirrlees Watson Company, Ltd., Glasgow, have recently received orders for 69 sets of condensers, practically all for war service work, aggregating approximately 1,400,000 lb. steam duty per hour.

SOUTH AMERICAN TRADE.—A circular issued on the 8th inst. by the British Bank of South America gives information on the trade of Brazil and Argentina in January last, on the basis of data supplied by its branches in the two countries. In regard to Brazil, the circular states that import duties, which were payable 40 per cent. in gold and 60 per cent. in paper, are now payable 55 per cent. in gold and 45 per cent. in paper, the modification resulting in a net increase of about 18 per cent. Exports of rubber to the end of October showed a falling-off of some 10 per cent. in quantity in spite of the improvement of 9.8 per cent. in sterling f.o.b. value. Export values for 10 months, from January to October, were: 1913, 130,000*l.*; 1914, 233,000*l.*; 1915, 432,000*l.*; 1916, 1,239,000*l.* It was generally considered that the German houses who had been buying and selling largely in the Argentine market since the commencement of the war, and had been large shippers to the United States, had anything from 50,000 to 100,000 bales of wool lying stored in the country, presumably to be ready for shipment to Germany immediately on the cessation of hostilities. The 5 per cent. proposed tax on exported commodities from Argentina had been recommended by the President of the Budget Committee for approval and was expected shortly to pass Congress.

TRADE WITH EGYPT.—Mr. J. W. Williamson, contractor, Cairo and Ismailia, writing to the journal, *The Near East*, states that one very essential condition to which any British firm striving to capture the Egyptian market must conform is that all gauges, sections and sizes of material must be manufactured to the metric system of measurements and quoted for on that system in Egyptian currency. The sizes in general use are rails weighing 5, 7, 9 and 12 kg. per metre run, fixed in pairs with five to seven steel sleepers to gauges of 50 to 60 and 75 cm.; tipping trucks are made of ½ to ¾ and 1 m. cube capacity, and so on all through. The metric system is in general use in Egypt, and at least 99 per cent. of the buyers of this class of material understand no other measurements and will not trouble to learn the English system. If the British public could be brought to see the amount of valuable time they waste working with our complicated system, and our manufacturers and merchants the volume of trade which is annually lost to them for the same reason, there would be some hope that advantage would be taken of the general upheaval brought about by the war to alter the same to the metric system, as the Germans did after their successful war against France in 1870–71.

STEAM TURBINES FOR LAND PURPOSES.

(*For Description, see Page 244.*)

Fig. 7. VARIATION IN CONDITIONS ON 2,000 K.W. INSTALLATION DURING TEST.

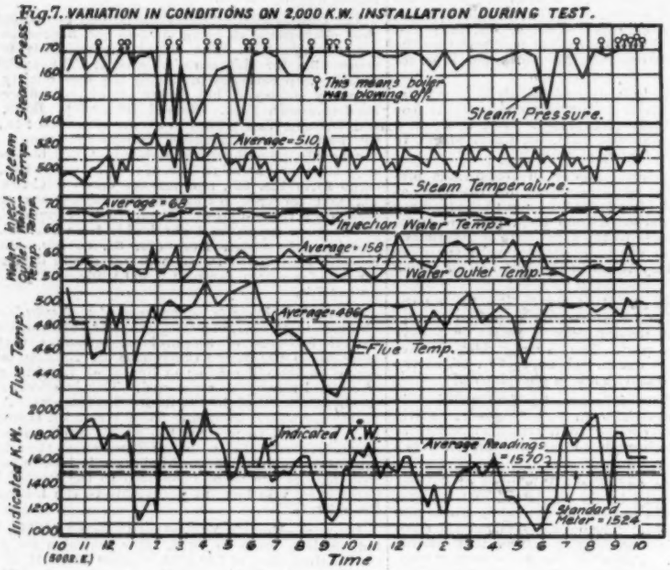
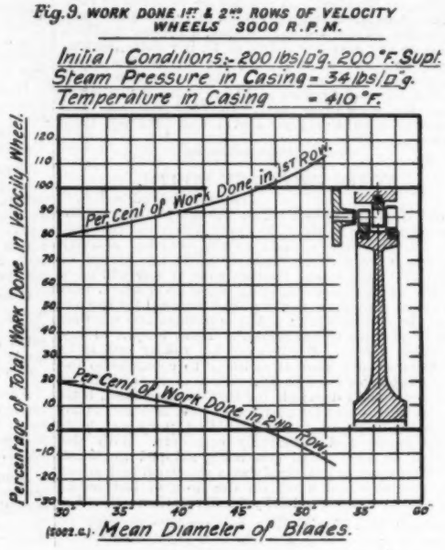


Fig. 9. WORK DONE 1ST & 2ND ROWS OF VELOCITY WHEELS 3000 R.P.M.


Initial Conditions:- 200 lbs/□"g. 200 °F. Sup!.
Steam Pressure in Casing = 34 lbs/□"g.
Temperature in Casing = 410 °F.
Percentage of Total Work Done in Velocity Wheel.
Per Cent of Work Done in 1st Row.
Per Cent of Work Done in 2nd Row.
Mean Diameter of Blades.

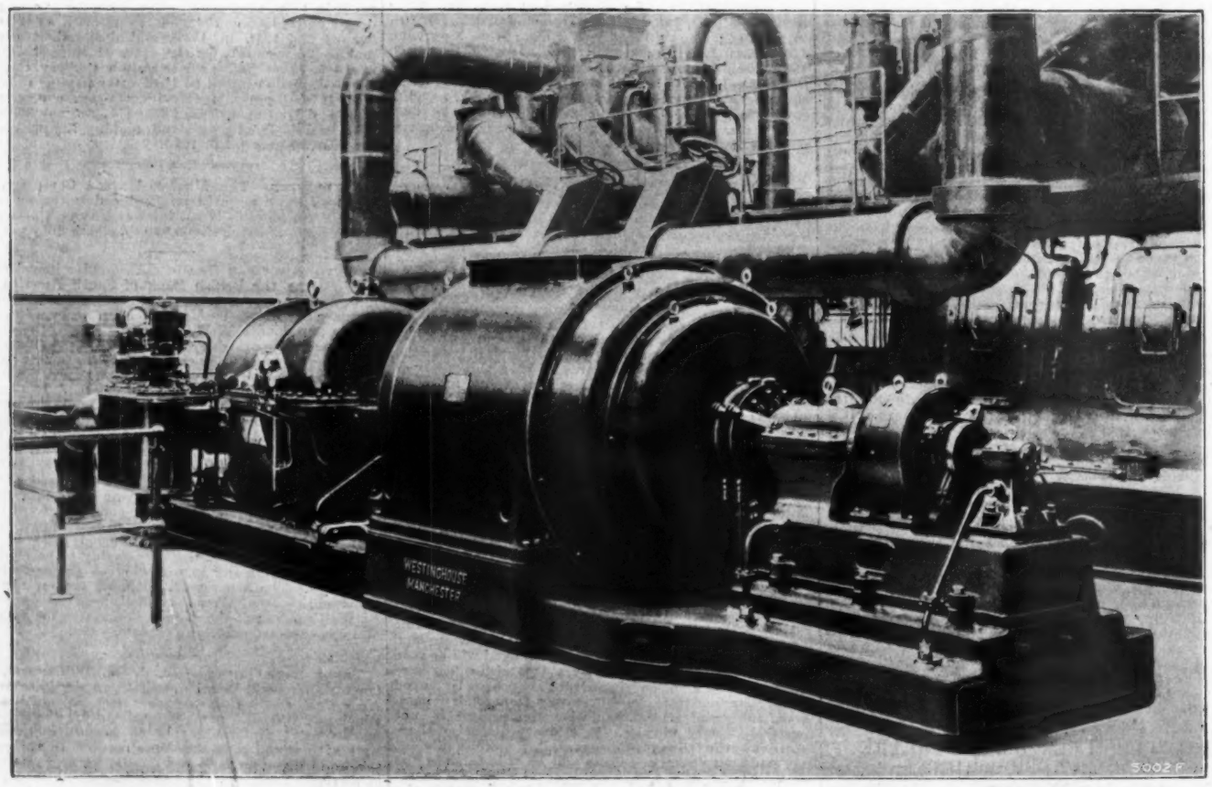


FIG. 8. 8000 KW. 3000 R.P.M. TURBO-ALTERNATOR FOR THE CHARING CROSS, WEST END AND CITY ELECTRICITY SUPPLY COMPANY, LONDON.

THE METRIC SYSTEM.—The enforced introduction of the metric system in the United States, making it by legislation the only legal system of weights and measures after a certain date, as has been proposed by several Bills that have been introduced in Congress, is regarded by many industrialists and engineers as a threatened calamity of the first order, says the *Engineering and Mining Journal*, New York. Such legislation, adds our American contemporary, would not merely mean the use of different kinds of weights and measures, as its advocates carelessly think, but would involve and lead to changes of the thousands of standards of materials and all sorts of units upon which the American industry is based. Manufacturers would be confronted by the necessity of changing gauges, patterns, &c., at costs running to 1,000,000 dols. even in individual cases. Engineers would lose the old factors and data of work, material, costs, &c., which from long experience have accumulated in their minds. Such records as are inscribed in Trautwine would be rendered useless, and so would it be with much of the State's engineering literature. Our contemporary then adds that an American Institute of Weights and Measures has been formed, the objects of which are the following:—"The maintenance and improvement of our present (English) system of weights and measures, for the good of our commerce and industry and the well-being of our country. The education of the people with respect to the importance of our weights and measures, through the dissemination of correct information with respect to them, and to the danger inherent to changes of our basic standards of measurement. The improvement of old and the development of additional standards as they may be needed by reason of new conditions in commerce, industry, science and engineering. The promotion of wise legislation for the conservation of our basic (English) units of weights and measures, and opposition to hasty and ill-considered legislation involving changes from our fundamental (English) standards."

PASSENGER LOCOMOTIVE FOR THE PARIS AND ORLEANS RAILWAY.

CONSTRUCTED FROM THE DESIGNS OF M. E. SOLACROUP, INGÉNIEUR-EN-CHEF DU MATÉRIEL ET DE LA TRACTION, BY THE NORTH BRITISH LOCOMOTIVE CO., LTD., GLASGOW.

(*For Description, see Page* 256.)

FIG. 1.

(*To face page* 256.)

PASSENGER LOCOMOTIVE FOR THE PARIS AND ORLEANS RAILWAY.

CONSTRUCTED FROM THE DESIGNS OF M. E. SOLACROUP, INGÉNIEUR-EN-CHEF DU MATÉRIEL ET DE LA TRACTION,

BY THE NORTH BRITISH LOCOMOTIVE COMPANY, LIMITED, GLASGOW.

(*For Description, see Page* 256.)

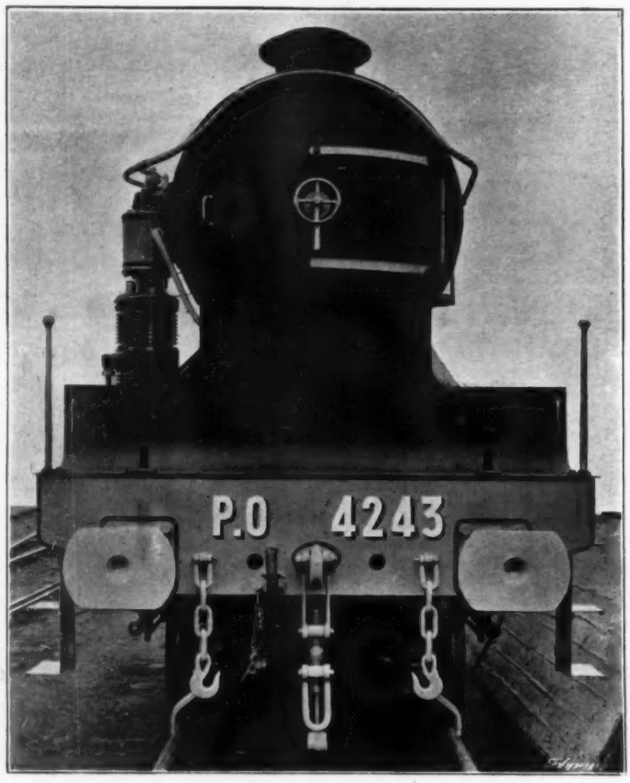


Fig. 2.

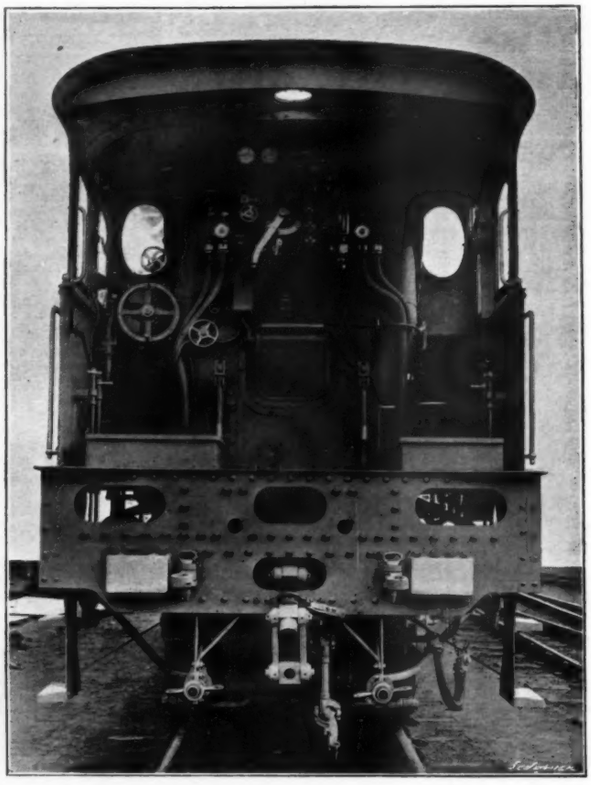


Fig. 3.

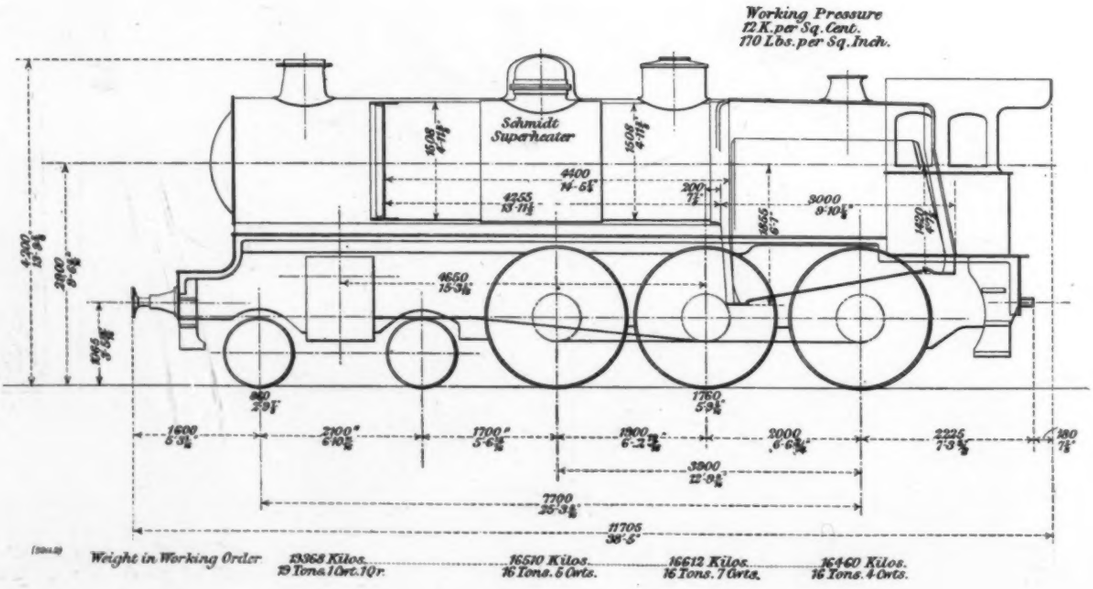
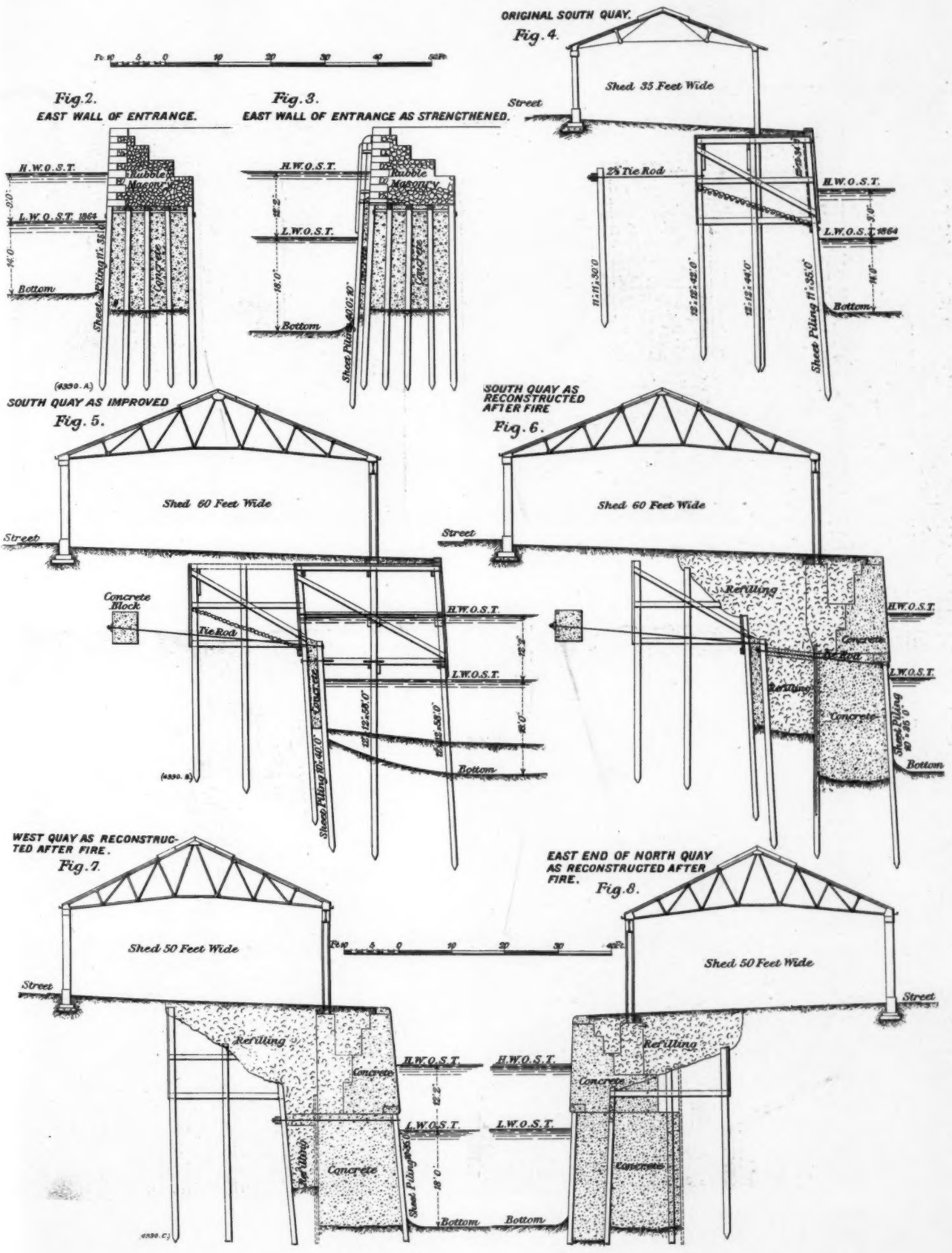


Fig. 4.

KINGSTON DOCK, GLASGOW; IMPROVEMENT AND RECONSTRUCTION.

MR. W. M. ALSTON, M.INST.C.E., ENGINEER OF THE CLYDE NAVIGATION.

(*For Description, see Page 257.*)



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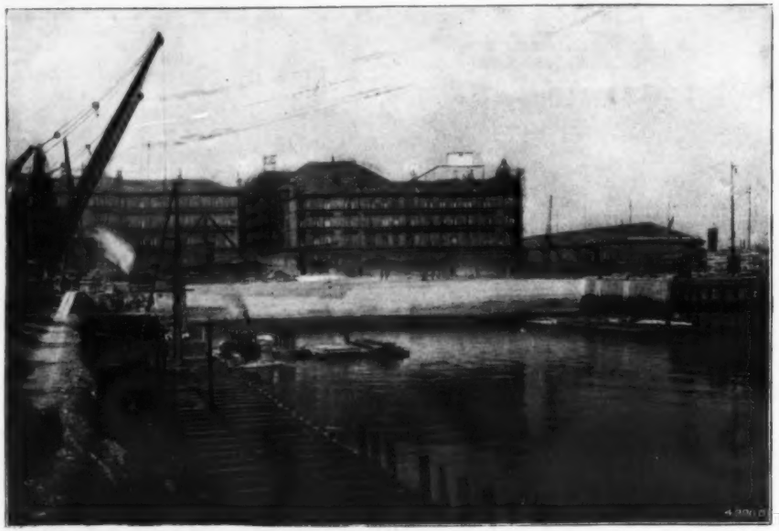

FIG. 9. WEST QUAY AND NORTH-WEST WALL COMPLETE, WITH WORK PROGRESSING AT SOUTH QUAY.

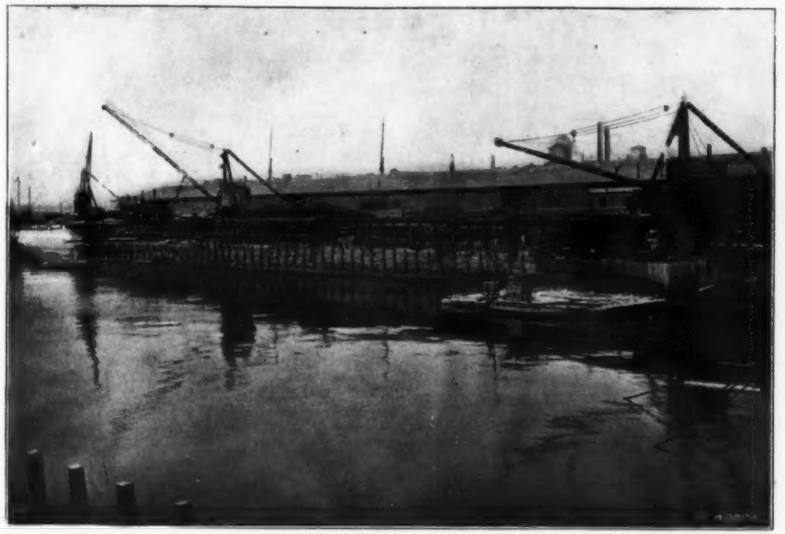

FIG. 11. VIEW SHOWING VARIOUS STAGES OF RECONSTRUCTION IN PROGRESS AT THE NORTH QUAY.

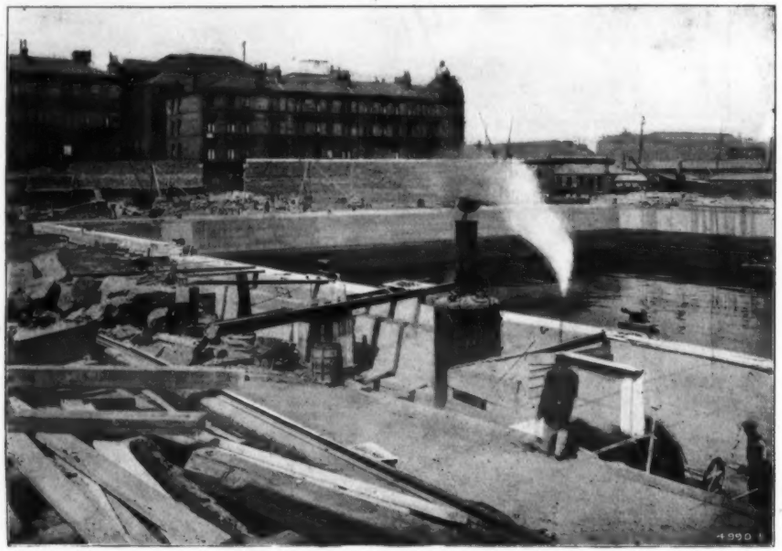

FIG. 10. WEST END OF DOCK COMPLETED, WITH CONCRETE SUPERSTRUCTURE OF SOUTH QUAY IN PROGRESS.

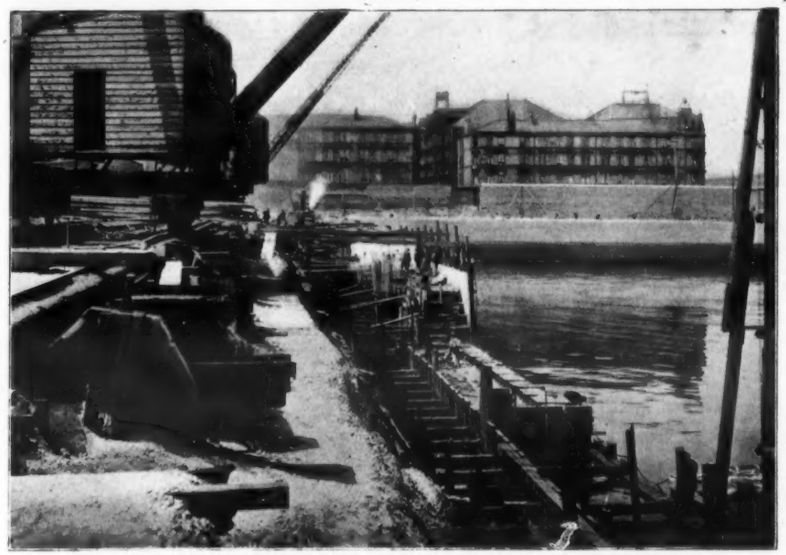

FIG. 12. VIEW SHOWING RECONSTRUCTION IN PROGRESS AT THE SOUTH QUAY.

(*To face page* 257.)

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The charge for advertisements is three shillings for the first four lines or under, and eightpence for each additional line. The line averages seven words. Payment must accompany all orders for single advertisements, otherwise their insertion cannot be guaranteed. Terms for displayed advertisements on the wrapper and on the inside pages may be obtained on application. The pages are 12 in. deep and 9 in. wide, divisible into four columns of 2¼ in. in width. Serial advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

Advertisements intended for insertion in the current week's issue must be delivered not later than 5 p.m. on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received not later than 1 p.m. on Tuesday in each week.

SUBSCRIPTIONS, HOME AND FOREIGN.

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"ENGINEERING" may be ordered from any Newsagent in town or country and at railway book-stalls, or it can be supplied by the Publisher, post free, at the following rates, for twelve months, payable in advance:—

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All accounts are payable to "ENGINEERING," LIMITED. Cheques should be crossed "Union of London and Smith's Bank, Limited, Charing Cross Branch." Post-Office Orders should be made payable at Bedford-street, Strand, W.C. 2.

Offices for Publication and Advertisements, 35 and 36, Bedford-street, Strand, London, W.C. 2.

We desire to call the attention of our readers to the fact that the above is our SOLE ADDRESS, and that no connection exists between this Journal and any other publications bearing somewhat similar titles.

TELEGRAPHIC ADDRESS } "ENGINEERING," WESTRAND, LONDON.
TELEPHONE NUMBERS—8663 and 8568 GERRARD.

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NOTICES OF MEETINGS.

THE INSTITUTION OF MECHANICAL ENGINEERS.—Friday, March 16, at 6 p.m., at the Institution of Civil Engineers, Great George Street, Westminster. Papers:—"Heat Treatment of Large Forgings," by Sir William Beardmore, Bart., Member, of Glasgow. "Heat Treatment of Steel Forgings," by Mr. H. H. Ashdown, of Newcastle-on-Tyne.

THE INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS.—Monday, March 19, at 6 p.m., at the Institution of Electrical Engineers, when a paper will be read by Mr. G. F. Gresham on "The Provision of a Telephone Exchange."

THE ROYAL SOCIETY OF ARTS.—Monday, March 19, at 4.30 p.m. Aldred Lecture.—"Memorials and Monuments," by Mr. Lawrence Weaver, F.S.A. (Lecture III). Wednesday, March 21, at 4.30 p.m. "Colour Printing, and some Recent Developments," by Mr. George W. Jones. Mr. Carmichael Thomas, Chairman of the *Graphic* and *Daily Graphic*, will preside.

THE INSTITUTION OF ELECTRICAL ENGINEERS: SCOTTISH LOCAL SECTION.—Tuesday, March 20, at 7 p.m., at the Princes Street Station Hotel, Edinburgh. Paper:—"Voltage Regulation of Rotary Converters," by Mr. G. A. Juhlin, Member.

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday, March 20, at 5.30 p.m. Paper to be submitted for discussion:—"The New Electric Power-House at Birchills, Walsall," by Mr. Ernest Matthew Lacey, M.Inst.C.E.

THE INSTITUTION OF PETROLEUM TECHNOLOGISTS.—Tuesday, March 20, at 8 p.m., at the House of the Royal Society of Arts, John Street, Adelphi, W.C. The following paper will be read:—"Sulphur in Petroleum Oils," by Mr. F. Mollwo Perkin, Ph.D., F.I.C., F.C.S. The chair will be taken by the President, Professor John Cadman, C.M.G., D.Sc., M.Inst.C.E.

THE LIVERPOOL ENGINEERING SOCIETY.—Wednesday, March 21, at 7.30 p.m., at the Royal Institution, Colquitt Street, when a paper will be read by Mr. L. Leighton, Assoc.M.Inst.C.E., A.M.I.Mech.E., entitled "Equipment of King George Dock, Hull." (This will be a joint meeting with the Manchester Section of the Institution of Electrical Engineers.)

THE ROYAL METEOROLOGICAL SOCIETY. — Wednesday, March 21, at 5 p.m., at Caxton Hall, Westminster, when a lecture on "The Formation of Mist and Fog" will be delivered by Major G. I. Taylor, R.F.C.

THE INSTITUTE OF METALS.—Wednesday and Thursday, March 21 and 22, at the Hall of the Chemical Society, Burlington House, Piccadilly, W. Wednesday, at 8 p.m. Annual general meeting. Papers on "The General Properties of Stampings and Chill Castings in Brass of Approximately 60/40 Composition." by Mr. Owen W. Ellis, B.Sc.; "Machining Properties of Brass," by Mr. Owen W. Ellis, B.Sc.; "Surface Tension and Cohesion in Metals and Alloys," by Mr. Sydney W. Smith, D.Sc., A.R.S.M.; "Aluminium Production by Electrolysis: a Note on the Mechanism of the Reaction," by Mr. R. Seligman, Ph.Nat.D.; "Annealing of Nickel Silver" (Part II.), by Mr. F. C. Thompson, D.Met., B.Sc. Thursday, March 22, at 4.30 p.m. and 7.45 p.m. Metal-melting discussion. Papers on "Metal-Melting as Practised at the Royal Mint," by Mr. W. J. Hocking; "Coal Gas as a Fuel for the Melting of Non-Ferrous Alloys," by Mr. G. B. Brook; "High-Pressure Gas Melting," by Mr. C. M. Walter, M.Sc.; "Contribution to Metal-Melting Discussion," by Mr. H. M. Thornton and Mr. H. Hartley, M.Sc.; "An Electric Resistance Furnace for Melting in Crucibles," by Mr. H. C. Greenwood, D.Sc., and R. S. Hutton, D.Sc.; "Ideals and Limitations in the Melting of Non-Ferrous Metals," by Mr. Carl Hering; "Metal-Melting in a Simple Crude Oil Furnace," by Mr. H. S. Primrose.

THE INSTITUTION OF ELECTRICAL ENGINEERS.—Thursday, March 22, at 8 p.m. "Machine Switching Telephone Gear," by Mr. F. R. McBerty, Member.

THE CONCRETE INSTITUTE.—Thursday, March 22, at 5.30 p.m., at Denison House, 296, Vauxhall Bridge Road, Westminster, S.W., when a paper will be read by Mr. W. Cleaver, M.Inst.C.E., entitled "The Rational Design of Reinforced Concrete Wharves and Jetties, with particular reference to those for Wet Docks having a permanent Water Level."

THE ROYAL INSTITUTION OF GREAT BRITAIN.—Friday, March 23, at 5.30 p.m. A discourse will be delivered by Mr. Edward Clodd, J.P. The subject is "Magic in Names." Afternoon lectures next week at 3 p.m. Tuesday, March 20. Professor John W. Gregory, D.Sc., F.R.S., Professor of Geology, Glasgow, on "Geological War Problems" (Lecture II). Thursday, March 22. Professor J. A. Fleming, M.A., D.Sc., F.R.S., Professor of Electrical Engineering, University College, London, on "Modern Improvements in Telegraphy and Telephony—Telegraphy" (Lecture I). Saturday, March 24. Mr. Stephen Graham on "Russian Idealism: the Russian Madonna" (Lecture I).

NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions now imposed by the Government on the importation of paper, and of the consequent shortage of supplies, readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk. Owing to the scarcity of paper it will be impossible in future fully to provide for a chance demand for this Journal.

NOTICE.

Owing to the recent Government restrictions, and to the enormous increase in the price of paper occasioned thereby, the Proprietors of "ENGINEERING" are compelled to advance the price of this Journal from 6d. to 8d. per copy. This increase will date from and include the present issue of Friday, March 16. The change will not apply to unexpired subscriptions.

ENGINEERING.

FRIDAY, MARCH 16, 1917.

ECONOMICS AT TECHNICAL INSTITUTIONS.

FOR some time there has been a growing feeling among a section of the members of technical institutions that the field of view of such societies might be widened. The consideration of technical matters is, of course, their main object, but engineering has also a business aspect, and unless the financial side is properly managed the demand for technical knowledge must be restricted. In some of the younger societies there has been quite an agitation to force the council to take an active part in business propaganda, but so far the heads of the institutions have very properly refused to allow their energies to be diverted into such channels. Experience has taught them the dangers and difficulties that attend in this country all attempts at combined action by manufacturing firms to push the interest of a trade, and they have steadily declined to risk the success of the bodies over which they preside by lending themselves to any such perilous enterprises. No disinterested person can doubt the wisdom of their action, for it is just at the time when competition is at its keenest that such demands arise, and it is then that combined action is most difficult and suspicion most awake. The moment that personal gain becomes an element in the proceedings of an institution there is a serious menace to the unanimity and feeling of loyalty which is essential to its success.

Nevertheless it is impossible not to sympathise with the feeling under the demand. Engineers in the past have often found themselves pawns in the hands of financiers and politicians, and instead of taking a part in the direction of the struggle have been used to further the interests of others rather than of themselves. The present war has demonstrated—if demonstration were needed—that the engineer is the greatest factor in the contest for and against world supremacy, and that he has practically no part in the management. There are many reasons for this, but the chief is that engineers, as a body, have little knowledge of economics in its wider aspects. With certain exceptions, they cannot hold their own in the company of those who control great movements, not for want of ability, but because they have not the necessary acquaintance with the principles of trade, exchange and finance. Many an engineer who in his youth has nursed the ambition of impressing his personality upon the construction of railways or docks or waterworks finds later that immediately he goes beyond the limits of technical matters he is helpless, and that he must mould and modify his schemes to fit the ideas of others more capable of gauging the needs and possibilities of commerce. This is an unsatisfactory condition of affairs, and it is one that may very rightly occupy the attention of the councils of our various institutions, seeing that it concerns the status of the profession and its efficiency in the world. It is entirely distinct from trade propaganda, prices and the like, and even from questions relating to tariffs.

What engineers need, in the first instance, is a firm grasp on the principles of commerce and finance, and when that has been obtained they must rely on themselves for the application of the principles to the matters that constitute their daily avocations. Already these principles form the subject of university courses, but engineers cannot afford the time to add such courses to their other curriculum, and may reasonably claim the assistance of their respective societies in their post-graduate days. As is befitting its position, the Institution of Civil Engineers has already led the way. In March of last year it invited Mr. Harold Cox to lecture before it on "Industrial Development," and this week a lecture on "Foreign Trade and its Relation to the Investment of Capital Abroad," by Mr. Edgar Crammond, of Liverpool, has been delivered. At further extra meetings, in the immediate future, there are to be lectures on the "Decimal System of Coinage, Weights and Measures," and on the "Standardisation of Engineers' Materials." Discussion follows the lectures, eminent men outside the ranks of the Institution being invited to take part. Nothing but good can be anticipated from this innovation, for not only are the lectures full of information, but, it is to be hoped, they will form the portal to further study and investigation by their hearers.

Mr. Crammond's lecture was a model of what such discourses should be, although its full value cannot be realised until it is in print, for it necessarily dealt largely with figures which are difficult to grasp as they fall from the lips of a speaker. British engineers find much of their occupation in executing works abroad, and nearly all these works are

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carried out by British capital. If that supply were cut off the practices of many of the older engineers and the prospects of numbers of the younger would suffer a severe decline, and hence the Institution has the keenest interest in understanding the conditions by which the source of the livelihood of its members is affected. We all of us know that our holdings of American securities have been the main factor in preventing the British sovereign suffering the same fall in New York as the German mark. According to Mr. Crammond we had before the war 600,000,000*l.* invested in the States, and this formed a fund by which we could pay for munitions and food, and upon which we could borrow. It is not many years ago that there was an outcry that the social legislation of the Government was driving capital abroad, and that our own industries were being starved. Possibly there was some truth in that, but keeping capital at home has its disadvantages. There was a period of three or four years following the revolution in Brazil and the Sherman Act during which the British investor almost closed his pockets against offers from abroad, and during that time Consols rose to 110, while other high-class securities gave little better return. Capital could not find adequate openings here, and the moneyed classes made little savings. This state of affairs was reflected in our exports, which were valued at 263,000,000*l.* in 1890, 216,000,000*l.* in 1894, and 255,000,000*l.* in 1899, and for some years during this period our annual investments abroad were about 22,000,000*l.* After the South African War money again began to pour abroad, and our exports rose from 300,000,000*l.* in 1904 to 426,000,000*l.* in 1907 and 525,000,000*l.* in 1913. Our loans do not go abroad in the form of bullion, but of manufactured goods, and each consignment acts as a commercial traveller to secure more orders. Further, they all find occupation for our shipping, and many of them for our engineers. Those of our profession who go abroad and those who stay at home are alike interested in the dissemination of the truth that foreign investments not only earn interest, but that they find work for a large portion of our population who otherwise would be insufficiently occupied.

It was impossible that a lecture like Mr. Crammond's should not touch on the question of trade within the Empire. Just now this subject excites much enthusiasm, and a great deal is written about it which ignores some very important facts. We all should like to see the Empire self-supporting, but for the present this is impossible. The Germans have long aimed at being independent of outside sources, but the grip of our fleet is the most serious menace from which they suffer. We must continue to trade with all the world, firstly because we cannot get all our food and raw materials within the Empire, and, secondly, because we must keep our shipping employed. It is physically impossible that 12,000,000 people in the Colonies should supply the needs of 46,000,000 at home. Even in the matter of wool we only get 75 per cent. of our supply from the Empire, while of timber we only get 16 per cent. As for cotton, the Empire only supplies 3 per cent. of our needs, so it is clear that we are very far removed from the time when we can become self-contained. It does not follow, however, that we should make no effort towards that end. The experience of the last two and a half years has shown us that the solidarity of the British race is something worth fighting for and paying for, and that our former policy of making cheapness our first aim is not only the pursuit of a false ideal, but is also very expensive in the long run. Our Colonies want capital and men, and it will be their business and ours in the future to offer inducement for both to keep as far as possible under the Flag. In that way we shall gradually increase our available supplies of raw material, and at the same time unite the race not only in sympathy, but in commercial interests.

Our commercial shipping has saved both the Empire and the Allies. Without it we could not have waged our world-wide war, and we cannot contemplate its reduction in the future. It is estimated that in 1913 it earned 162,000,000*l.* sterling by an expenditure of 100,000,000*l.* In addition, it brought enormous business to London for underwriting, banking and discount, and in some way or other found employment for 830,000 persons. Its services ranked high among our so-called "invisible exports," which balance the difference between exports and imports. Without our annual investments abroad, our shipping must decline; it is engaged in carrying overseas the goods brought against the investors' credits in London, and in bringing back the food and raw materials which represent the interest on the 4,000,000,000*l.* we have contributed to the exploitation of foreign countries. Only about one half of this is within the Empire, and, consequently, for a very long time our trade must follow in a large degree its accustomed courses. Indeed if we want to make up our war losses we must seek customers all over the world, and take payment for our goods in what they can best supply.

Economics is not an exact science. It is seldom that it offers a definite solution to a problem. But it is of immense use in preventing us from running into mistakes, and it does reveal the principles underlying the flow of trade. A study of it widens the vision and enables forecasts to be made which, if not of the nature of certainties, have at least a fair value as probabilities. Although this country has been productive of great economists the science has never taken wide root, and hence we see fallacy after fallacy propounded in newspapers, pamphlets and books, while the platform is prolific of them. Most of these arise from want of perspective; the vision is concentrated on one facet of a subject, and the others are ignored, because they are not in the view. Half the wrangles between Free Traders and Tariff Reformers would never have arisen if the respective advocates had taken the trouble to understand their opponents' position and the full results of their own policy. At a time when old policies are disappearing and new ones are clamouring for adoption we cannot have too many lectures like that of Mr. Crammond, for it was full of warnings against precipitate action that would be followed by a revulsion of feeling. It cannot be too strongly insisted upon that all policies before the public have their advantages, but that these advantages have always to be paid for. Sometimes the demand for payment is immediate and sometimes it is deferred. In the same way the advantages sometimes accrue slowly and sometimes rapidly. The point to be determined is whether the advantages, present or prospective, are worth what they will cost us sooner or later. So far in the war we and our Allies have been saved by British wealth quite as much as by valour, and it is most desirable that the principles leading to wealth should be widely discussed, remembering always that they cannot be entirely measured on a monetary basis. In the production of wealth the engineer is the most important factor, for he increases the efficiency of human effort many times by the application of machinery, and it is therefore only right that he should be educated in economic principles, so that he may take a leading part in moulding opinion and legislation in relation to financial and commercial matters.

THE RULES OF SHIP REGISTRY SOCIETIES.

THE formation in 1890 of the British Corporation for the Survey and Registry of Shipping was an event of far-reaching importance to all concerned in the design, construction and maintenance of ships for the merchant service, and that the progressive spirit which animated the original committee of management, and their technical staff, has been maintained and developed is shown by the form in which their new Rules and Tables for 1917 have been drawn up and issued for the guidance of owners and builders. There is no doubt that much of the progress which has been made in recent years in the modification and simplification of the rules of registration societies is directly due to the energy and ability with which the technical staff of the British Corporation tackled the problem of devising rules which would allow to builders and owners the maximum of latitude in the selection of suitable scantlings for their proposed designs, and which would, at the same time, satisfy the conditions of strength demanded by the Corporation. It is at once apparent that the new rules embody in a remarkably comprehensive manner the principles of design for which ship designers have long contended, and that they mark a very decided step in advance of all previous rules and tables in that, for the first time, a scientific basis for the selection of scantlings appropriate to a special design is made use of. The embodiment in the rules of the new principle upon which constructional plans and midship sections will in future be prepared for submission is an achievement of which the British Corporation may justifiably feel proud, and in the successful carrying through of the vast amount of work involved Mr. J. Foster King, the capable chief surveyor of the British Corporation, and his staff are to be heartily congratulated. The essential feature of the new form of the rules, as compared with the old, is the removal of approximations often based on dimensions which have nothing to do with the work of particular parts, and the substitution of control of scantlings by formulæ which have a direct relation to the work to be done. Items of construction for which no previous regulations have been published are dealt with; in short, freedom of design has been granted to a degree never before attempted, and the benefits which this freedom will confer on builders and owners cannot well be estimated.

Rudders and stern frames have undergone considerable modification within recent years owing to the increasing use of the balanced types of rudder and the adoption of the cruiser form of stern. Provision is made under the section dealing with keels, sterns and stern frames for the construction of stern frames without a back post, and a rule for scantlings is furnished. The determination of the size of rudder stock, arms, &c., in a classed vessel was for many years governed by the dimensions of the ship—a practice which gave undue influence to factors which have little or no bearing upon the matter. In their original rules the British Corporation for the first time put this important item upon a satisfactory footing by basing the dimensions upon the governing conditions of immersed longitudinal area and speed of vessel. The new rules contain formulæ by means of which the builder can calculate the required size of rudder stock, arms, coupling bolts, &c., for ordinary and balanced rudders. The inclusion of the formulæ for balanced rudders with top and bottom bearings, and for balanced rudders of the spade type, is of special interest as representing one of the most modern developments in shipbuilding. We believe these are also the first classification formulæ dealing with these types of rudder. As a general adoption of the principle of the balanced rudder in high-speed vessels may be looked for in general practice, and of the spade type for twin-screw high-speed vessels of the Channel type, the utility of the new departure is obvious.

The introduction under classification control of simplified and more open methods of construction of double bottoms was due to the work of the British Corporation, and the measure of success which has attended the introduction of this open-floor system is shown by the frequency with which it is now adopted, and by the fact that it is now adopted as the standard construction under the new rules. The practical advantages of the newer and more open system during construction and in the repair and examination of spaces within the double bottom are such as readily to commend themselves to builders, owners and surveyors. The veritable maze of small compartments—difficult of access for work during construction and for repair after damage—formed by the intersection of floor plates and intercostal longitudinal girders is done away with to a very large extent, and to this desirable state of matters the spacing of the intercostal longitudinal girders, 15 ft. maximum amidships, contributes in no small degree. Damage to the bottom plating forward, due to "slamming" or the pounding action of the waves when the vessel is running in ballast, is of somewhat common occurrence, and the new rules amplify the provisions previously made for the elimination of this trouble by increasing locally the thickness of shell plating and by the fitting of double-riveted frame and intercostal connections.

The new rules for the determination of the

scantlings, &c., of frames are remarkable for their flexibility and for the eminently sound basis upon which they are founded. The frame spacing, number of rows of stanchions, unsupported length of frame, and draught of ship are the factors made use of in the two formulæ which determine the scantling of frames. Each or all of these factors may be modified by the designer to suit his requirements as to structural arrangement, or the section which he finds it most convenient to work, and it may fairly be said that it now lies with the designer to adjust these various factors so as to give the best possible result for his requirements. The latitude which is allowed in the fixing of heights of floors and bracket connections to frames, depth of beam knees, frame spacing, &c., may at first prove a trifle disconcerting to the designer, and it will certainly induce him to investigate very carefully the possibilities of each variation, but the advantages to be gained are so great that they will far outweigh the extra time and trouble involved in the preparation of the section for submission. The depth and thickness of floor plates and the size of beams are similarly regulated by formulæ which make it possible to proportion correctly the scantlings to the work which these members of the structure are called upon to perform and which are based upon the sound theory that span and load should be the determining factors in fixing the scantling of beams. The treatment of deck girders and pillars is closely associated with that for deck beams, and here again the new rules provide formulæ for all cases and take account only of the essential factors in each case.

The whole question of watertight subdivision and the strength of bulkheads was exhaustively dealt with by the recent Bulkhead Committee, and rules governing the degree of subdivision and the construction of bulkheads which are now accepted as the standard were formulated. The question of subdivision by means of watertight bulkheads was considered by this committee mainly in its bearing upon the question of safety, and the construction of bulkheads recommended was deduced from actual experiment; but so far as registration societies are concerned the main consideration governing the fitting and construction of bulkheads is strength. It is therefore appropriate that the new rules governing the strength of bulkhead plating and stiffness should conform very closely to the findings of the Bulkhead Committee. Only those bulkheads which conform to the rules governing the construction, position and tests of watertight bulkheads are to be recorded in the register book as watertight, and this fact should encourage the making of divisional bulkheads watertight.

The section and tables dealing with longitudinal material, such as deck plating and stringer bars and shell plating, form an admirable illustration of the success with which the principle of the determination of scantlings with strict regard to the work performed by each item of structure has been applied. Length, breadth, draught and freeboard are the governing factors in the determination of the rule scantlings for rule frame spacings, but provision is made in the rules for variation in draught, freeboard or frame spacing in the case of the shell plating tables, and for variations of number of decks, freeboard, beam spacing and 'tween-deck height in the case of deck plating. It must be conceded that tables which take account of so many variables, and yet maintain a uniform stress intensity in the material, form a most remarkable piece of work and reflect credit on all concerned in their production. The important subject of riveting is dealt with in detail for all important items of structure, and the tables furnish all the required information as to details of spacing, &c.

The special section dealing with vessels for carrying oil conforms closely to that governing the construction of ordinary vessels, the designer being left with a very free hand as to internal arrangements, &c. Formulæ for the thickness of plating of vertical circular tanks for carrying oil in bulk, and for the thickness of circular tunnel plating where tunnels are carried through oil spaces, are given. Among the minor items no change of importance has been made except perhaps in the section on pumping arrangements, where the formula for determining the diameter of suction pipes recommended by the Bulkhead Committee has been inserted. The rules for machinery have been very considerably rearranged, extended and simplified, but no alteration on a scale corresponding to those which have taken place in the ship section has taken place. Engineers will find the application of the rules simplified, but they will not be called upon to reconsider their designs as will the shipbuilder.

The new rules mark a very decided step forward on the part of the British Corporation, not only on account of the excellence of the principles underlying them and the skilful manner of the application of these principles in tables and formulæ, but also by reason of the fact that there is now allowed scope for the originality and resource of designers on a scale never hitherto dreamt of in connection with registration societies' rules, and this will operate entirely for the good of ship design in general. To all concerned in the production of the new rules the thanks of shipbuilders and owners are due for their very successful effort to meet modern conditions, and the proof that a rigid adherence to inelastic rules is not the policy of this most progressive society.

THE RAILWAY WAGON PROBLEM.

A GOOD deal has happened since we last referred to the railway wagon problem (ENGINEERING, December 22, 1916), but much remains to be done. We expressed the opinion that railway companies should extend the mutual user of wagons and in other ways devote their attention to the prevention of light or empty wagon mileage. This has been done in respect of open goods and coal wagons suitable for general purposes belonging to the railway companies which are now under Government control. These vehicles may now be loaded to any station on or beyond the line of any of the controlled companies, irrespective of the ownership of the wagons or of the routes by which they were received, either full or empty. In other words, railway-owned open goods wagons are now used indiscriminately, no matter on what line they may be, instead of, as hitherto, being immediately returned to the owning company. This has inevitably saved shunting work in sorting out "foreign" wagons, while empty vehicle haulage has been much reduced. In saying this, however, it is not overlooked that empty mileage cannot be abolished. The flow of traffic can never be equal between all points, and it will always be necessary to supply certain ports and manufacturing centres with empty rolling-stock, while working such stock away from places at which the inward loading exceeds the outward. Indeed, the common user of wagons is in itself the cause of some amount of empty vehicle haulage. To demonstrate this it is necessary to explain that there are 12 wagon distribution areas, or zones. These are the respective systems of the Great Central, Great Eastern, Great Northern, Great Western, Lancashire and Yorkshire, London, Brighton and South Coast, London and North-Western, London and South-Western, Midland, North-Eastern, South-Eastern and Chatham and the Scottish companies. Smaller railways are associated with one or other of the larger lines for the purpose of rolling-stock arrangements—*e.g.*, the London and North-Western company is responsible for the supply of wagons to the Cambrian, Furness, North Staffordshire, Oldham, Ashton and Guide Bridge, and Wirral railways. As between each of the 12 principal areas records are kept at each junction of the common user stock exchanged and daily debit or credit balances are prepared. On the basis of these records a specially constituted rolling-stock committee sitting at the Railway Clearing House notifies each company what adjustments have to be made either by payment or receipt of stock.

From this brief statement it will be apparent that what we have described as being applicable to individual stations or ports may apply to a rolling-stock area, viz., that it may regularly load to other lines more wagons than it receives from them, or *vice versa*. This is happening at the present time. For obvious reasons in connection with the war the southern companies receive more loaded wagons from other lines than they send to them. For example, the Great Western Railway will be handing the London and South-Western Company more wagons than it receives. This difference in the exchange has to be adjusted by payment of empty wagons by the London and South-Western Company. But the Great Western Company may require empty wagons in the Midlands or at Bristol or for payment of adverse balances to the London and North-Western at northern junctions. Obviously, therefore, empty vehicle haulage has to take place, and to the extent to which it is a feature of the new method of rolling-stock distribution empty vehicle mileage must continue to be a factor. It may be taken, however, that empty train and vehicle mileage has been greatly reduced.

We should mention that wagons of exceptional length or type, as also covered vans of all descriptions, bolster trucks, cattle wagons, and vehicles constructed for conveying heavy and bulky traffic are not used in common, but are still worked on the old basis of company ownership.

Having made so material an advance in the economic use of railway-owned rolling-stock, the question naturally arises as to the present position of the privately-owned wagon. Nearly three months have passed since the order in Council was announced by which the Board of Trade were empowered to order the taking possession of any private owner's wagons and to use them in such manner as they think best in the interests of the State, on such conditions as to payment, use and otherwise as may be provided. Yet little progress seems to have been made, and trains formed of empty privately-owned wagons are still a feature of railway operation in this country. We understand that, in connection with the demand for rolling-stock to be supplied for use in France, strong representations were made to the Government in favour of the taking over of privately-owned wagons. It seems, too, that the Scottish railways have had conferences with wagon owners and agreed upon a scheme. This was to have come into operation on February 5, subject to the approval of the Board of Trade. Judging by the fact that it has not come into force, it may be taken that the approval of the Department has not been forthcoming. We may also premise that this is in some way due to the possible effect of the Scottish agreement on the larger matter of the English and Welsh privately-owned wagons. As regards the latter a meeting seems to have take place between the President of the Board of Trade and representatives of the Railway Executive Committee and of the owners of railway wagons. No announcement of the result of this conference has been made, but a committee has been formed to continue negotiations.

There are many very considerable issues, but the dominating factor is that the haulage of empty rolling-stock is wasteful and should be minimised. Bad as it is at any time, it is doubly so in a period of national emergency such as the present, and no time should be lost in bringing the negotiations to an issue. Meanwhile we may profitably direct attention to a scheme of utilisation of privately-owned wagons which has been developed by Mr. John A. F. Aspinall, General Manager of the Lancashire and Yorkshire Railway. It is to secure to the railway company the right to use traders' wagons on their return journey for loading general goods traffic, payment being made for the time the vehicle is in use.

After completing a journey the wagon is loaded in its homeward direction with ordinary traffic. Steps are taken to record the time each vehicle is taken possession of by the railway company for loading, and payment is made from that time until it is unloaded and sent forward to the owning company. The rate of payment is 1*s.* per wagon per day or part of a day of user, Sunday being regarded as a *dies non*. Special steps are taken to secure that no wagon shall be unduly delayed on its return journey, and the agent at the station to which a vehicle conveys general goods traffic is notified that it must be discharged and sent on to the colliery on the day of arrival. A certificate has to be given that this order is carried out, and any failure is investigated.

We congratulate Mr. Aspinall on having developed this scheme, but it ought not to be regarded as other than a "half-way" stage. The full and unrestricted

use of all wagons, whether owned by railway companies or traders, is the end to be striven for, and we feel that there has already been too much delay in seriously tackling the problem.

NOTES.

THE STRENGTHENING OF CHARING CROSS BRIDGE.

IT is gratifying to note that the Bill for strengthening the railway bridge at Charing Cross passed its second reading in the House of Commons on Tuesday last by a majority of 184 to 56. The usual disingenuous speeches were made in opposition to the measure. No one, of course, admires the present bridge as a work of art, but it is undeniable that its appearance will be improved by the steps taken to strengthen it, and were the advocates of a vast expenditure of public money on the beautification of London consistent, they should express gratification at funds being found from private sources for a substantial betterment of the amenities of the Thames. The real, but of course unavowed reason for much of the opposition to the scheme lies in a desire to depreciate the value of the assets of the railway company. If by a refusal of the powers sought the company can be debarred from adequate use of its own property, this property may be purchasable at a considerable reduction on its fair value. The same plan was, it will be remembered, adopted with a view to depreciating the value of the Metropolitan water undertakings. If the community decides after the war to spend some millions of public money in beautifying the metropolis the scheme will be in no way interfered with by the proposed strengthening works. Indeed, the company have agreed that if the bridge be purchased within 10 years of date the sum expended on the new works shall be deducted from the compensation paid. In the meantime the public that uses the railway will benefit by the better service it will be possible to maintain. It is always interesting, even if unedifying, to note the assurance with which politicians express confident opinions on difficult technical questions as to which they are necessarily ignorant. In the present case, in moving the rejection of the measure, Sir W. Essex declared that the whole thing was a "flimsy contraption." From "Who's Who" we learn that this gentleman's qualifications for posing as an authority on structural engineering have been acquired in the paperhanging industry, a pursuit which, though no doubt harmless and necessary, would be regarded by few as affording an adequate training in either the theory or practice of bridge building.

THE SPRING MEETING OF THE INSTITUTION OF NAVAL ARCHITECTS.

As probably every member of the Institution of Naval Architects is very actively engaged, directly or indirectly, in war work, it is gratifying to find that a programme of thirteen papers has been arranged for the forthcoming spring meeting, to be held in London on the 28th and 29th inst. The work of adding to and maintaining the efficiency of the naval fleet devolves almost exclusively upon members of the Institution, while others are occupied on the important work of building merchant ships, particularly of the cargo type, to counterbalance the destructive operations of the German submarines and mines. In view of this, and of the necessity for reticence in all work intended for the prosecution of the war, it is not surprising that the papers should be more or less of a theoretical tone. We are glad, however, that the question of standardisation as applied to the machinery for cargo boats is to be discussed, as there is room for free expression of opinion regarding the value of standardisation. A contribution on this subject is the first paper to be read at the meeting, and its author is Mr. D. B. Morison, who has great experience with cargo-ship machinery. The second paper is "On a Method of Obtaining for Ship Design the Spacing of Bulkheads according to the Rules of the International Convention," the author being Mr. W. J. Lovett, who will no doubt give us the Belfast point of view. At the afternoon meeting, on the 28th, Mr. James Montgomerie, B.Sc., Chief Lloyd's Surveyor at Glasgow, will deal with "Stress Determination in a Flat Plate," Mr. E. Benvenuti, Genoa, will read a paper on "The Closing of all Ship Side Apertures from the Bridge," and Mr. Thomas Graham one on an apparatus for interpreting stability for the use of shipmasters. It has been found possible to arrange for an evening meeting, which is always appreciated, especially by the large number of young members of the Institution in the London area. Professor Dalby will read a paper at it on "The Strength and Inner Structure of Mild Steel." The second paper is by Lieut. W. A. Scoble, R.N.V.R., and is on "Design of Pin Joints based on Ultimate Strength." On Thursday, the 29th inst., meetings will be held in the morning and afternoon. Mr. W. J. Luke will contribute the first paper of the day on "Further Experiments upon Wake and Thrust Deduction Problems," a subject to which he has devoted a large amount of time and experimental research at the model tank at Clydebank Yard, and regarding which he has made several valuable contributions, in papers and discussions, at the Institution. Mr. J. J. King-Salter, R.C.N.C., will read the second paper on "Some Experiments on the Influence of Running Balance of Propellers on the Vibration of Ships," while Sir George Greenhill, F.R.S., will contribute the third paper, on "The Theory of Wave Motion on Water." At the evening meeting the first paper down for consideration is by Mr. J. H. Macalpine, and is on the "Marine Application of Reduction Gears of Floating Frame Type." Mr. P. A. Hillhouse, B.Sc., and Mr. W. H. Riddlesworth, M.Sc., M.Eng., will jointly contribute a paper "On Launching," while Professor W. Hovgaard will read the last paper, which is entitled "Buoyancy and Stability of Submarines." A feature of the meeting will be the first presidential address of the Earl of Durham, who took office at the beginning of the meeting a year ago.

LITERATURE.

The Submarine Torpedo Boat: Its Characteristics and Modern Development. By ALLEN HOAR, Junior Member American Society of Civil Engineers. New York: D. Van Nostrand Company; London: Crosby Lockwood and Son. [Price 9*s.* net.]

AT the present moment there is probably no subject of more universal and immediate interest to all nations, belligerent and neutral alike, than the potentialities of the submarine, particularly in its newer and typically Teutonic rôle as the instrument of "frightfulness" chosen by the Central Powers for the carrying out of their "blockade" of the British Isles. The measure of success which has attended the operations of the German submarines in their operations against unarmed and slow-moving merchant ships, also the well-advertised achievement of the Deutschland in its spectacular dashes across the Atlantic, have focused attention upon the achievements of the later types of submarine and at the same time have given rise in the minds of the non-technical public to some highly imaginative but wholly baseless beliefs in the powers of the submarine. Singularly little technical information on the subject of the construction, performances and development of modern submarines is available to the general public, and it is safe to say that at the outbreak of war very few people, other than Admiralty officials and those actually engaged on the design and construction of these vessels, had anything more than a hazy general idea of their shape and functions and possible performances, and to this fact must be attributed many of the misconceptions of the present day.

It is as yet too early to make any definite assertions as to the military value of the submarine as proved by the supreme test of war, for, although certain outstanding offensive performances have been recorded to the credit of both the British and German navies, no records have been published as to the losses entailed in the achievement of these successes, and it is therefore quite impossible to equate effort and achievement in the military sense. It is also to be noted that in practically all the cases of success reported the vessel attacked has been either stationary or moving at a speed little, if any, in excess of the submerged speed of a submarine—the outstanding exception to this being the case of the torpedoing of the German destroyer S 126 by the British submarine E 9. As a commerce destroyer acting against unarmed, and in the early days unsuspecting merchant ships, the submarine has naturally achieved a considerable measure of success, but even here no record of the cost in submarines of the measure of success already achieved is available, and it is thus impossible to assign an efficiency value to the submarine in this sphere of activity. Of the positive results of the commerce-destroying activity of the submarine there is unfortunately ample evidence, but the results obtained to date, by the recently announced intensified "blockade" of these islands, are such as to lead to the belief that the counter-measures adopted are proving successful and will ultimately reduce submarine activity to the sphere of furtive raids.

While it may well be that the activities of the present types of submarine, whether they be directed to their legitimate work of destroying enemy warships or to the destruction at sight of merchant ships, may be effectively checked by the counter-measures in use, it by no means follows that this state of matters will continue. The very fact of failure in certain respects will, along with the knowledge and confidence derived from successes, provide the necessary lessons and stimulus for the design and construction of new and improved types of submarine, and so continue the vicious circle of destruction which for the present represents progress in this branch of engineering science. In his preface, written in July, 1916, Mr. Hoar truly remarks that "The present European conflict has aroused a general interest in the submarine torpedo-boat"—and the developments of the latest phase of German submarine activity certainly give point to his words and broaden the basis of their application. It is therefore with pleasure that we welcome the publication at this time of "The Submarine Torpedo Boat," a volume descriptive of the historical and practical development of the modern submarine, its probable future development, and the means of defence against its attacks—the whole being written with a view to the requirements of the non-technical reader rather than the production of a theoretical text-book.

In the first chapter are outlined the successive stages of development from the year 1620, when Dr. van Drebbele demonstrated the practicability of under-water navigation on the Thames, down to the year 1899, about which time the development of the submarine, as an effective arm of the naval service, may be said to have commenced. A short outline of the development of the submarine from 1900 onward follows, and included in this chapter are some particulars of the American M 1, laid down in 1914, and the German boats U 9 to U 16. The first submarines for the British Navy were laid down in 1901 at the works of Messrs. Vickers at Barrow-in-Furness, and were of the Holland type—vessels of which type were at that time doing satisfactory work in the United States Navy. These vessels were 63 ft. 10 in. long, had a submerged displacement of 120 tons, and speeds of 7.4 and 5 knots in the surface and submerged conditions respectively. That steady progress was made in the development of this class is shown by the fact that the original vessels of the "E" class—a class which has especially distinguished itself in the present war—which were laid down in 1910, were 176 ft. long, had 800 tons submerged displacement, and had surface and submerged speeds of 15 and 10 knots respectively. Important developments in size, speed and offensive power have taken place since that date, and particularly under stress of war necessity, but of these it can only be said that they widen the mental horizon of even the expert in submarine design and bring some of the speculations of a short time ago into the realm of practicability. It is perhaps of interest to note that the figures given for the United States submarine M 1, laid down in 1914, and which Mr. Hoar claims as the equivalent of any of the foreign boats, compare none too favourably with the figures given above for the British "E" boats laid down in 1910. The corresponding figures for M 1 are: displacement, submerged, 630 tons; surface speed, 14 knots; submerged speed, 10.5 knots. Nor can one agree entirely with Mr. Hoar in his expressed conviction that with the present dual power system a limit to

the speed and radius of action in the submerged condition has been reached. With the motive power for surface running confined to the present type of heavy oil engine it may be granted that the increase in power required for a larger and faster vessel will require an increased proportion of the total displacement and a consequent decrease in the proportion available for submerged propulsion, but it is by no means certain that the heavy oil engine has yet reached its maximum efficiency per unit of weight, nor are the possibilities of other dual-power systems at present in use to be ignored.

Under the title "Characteristics and Requirements" are enumerated many of the troubles peculiar to this type of vessel in service, together with notes on some of the qualities which it is desirable to embody as aids to more efficient and comfortable working. In the former category may be mentioned the difficulties incidental to the effective use of the torpedo armament due to several causes, of which the chief are the difficulty of estimating the distance and speed of the target as revealed in the periscope image and the difficulty of keeping the fixed torpedo tubes trained on the object. Among the desirable qualities may be mentioned increase in controllability when submerged, reliability of power plant, increase in speed, and improvement in habitability for officers and crew. All these and other points are dealt with by Mr. Hoar.

Under the heading "Types of Submarines" several points of interest are discussed, the first of which is the distinction denoted by the terms "submarine" and "submersible." To the general public the term submarine embraces all war vessels capable of service under water; but to the expert the term "submarine" refers to vessels designed and used primarily for service in the submerged condition, while the term "submersible" refers to vessels partaking more of the nature and form of surface craft but capable of being submerged at will. As in most modern vessels of the submarine class the ratio of power for surface propulsion to power for submerged propulsion is very high—in some cases as high as 3 to 1—the distinction becomes largely a matter of form of hull, and the retention of the terms is hardly justified. Broadly speaking, modern submarines may be divided into two main classes, viz., those in which the design of hull is such as to favour stability and propulsion under water, and those in which the design of hull is such as to favour stability and propulsion on the surface. In the former class a single-hull construction is used, the section at any point of the length being approximately circular and the general outline cigar-shaped. The reserve of buoyancy in the surface condition is small and the water ballast required for submerging is easily contained in tanks built into the single-hull structure. About 6 per cent. of the submerged displacement is a fair average for the reserve buoyancy of this class in the surface condition. In the latter class a double-hull construction is adopted, the outer hull conforming approximately, and especially as regards its upper part, to the form of an ordinary surface vessel of high speed, and the inner hull—which extends over the greater part of the length—approximating to the single-hull type previously described. Part of the space between the two hulls is used for the stowage of the water ballast necessary to submerge the vessel. In the surface condition this class has a reserve buoyancy of from 30 to 40 per cent. of the submerged displacement, and is consequently more seaworthy, and on account of its form better adapted to surface propulsion than the "submarine" type. The stability of both classes is discussed by Mr. Hoar, both for the surface and submerged conditions, in language which does not make his reasoning at all clear, but his general conclusions as to the superior stability of the single-hull type in the submerged condition and of the double-hull type in the surface condition may be accepted as generally correct.

The methods of submergence—diving with the axis of the vessel inclined to the horizontal and controlled by the action of the horizontal rudder aft, and the "even keel" method, using hydroplanes forward and aft—are examined and discussed, and a method of overcoming some of the difficulties incidental to submergence suggested. This method consists in the placing of the propellers at the fore end of the boat instead of at the aft end as is usual. That some benefit would accrue in the matter of stability while diving is undoubted, but there appear to be serious objections to the proposal as, apart from the obvious objections from the point of view of screw efficiency and liability to damage due to the exposed position, there would seem to be a serious congestion of space at the fore end in the vicinity of the main torpedo armament of the vessel.

The chapter on design, embracing as it does the questions of type, stability, habitability, radius of action, navigation, signalling apparatus and armament, as well as the effect of form upon resistance, and speed and power estimation, is a somewhat long one in which the author seeks to point out the relative importance of each of these items. The inadequacy of many of the fittings at present in use and the direction in which improvement should be sought is pointed out, but the whole question of design is so involved that it is obviously impossible to do justice to it in one chapter and equally unprofitable to discuss that chapter in detail.

That Mr. Hoar is not impressed with the performances of the Diesel engine as applied to submarine propulsion is obvious throughout the book, and that in many respects his expressed objections are sound is amply borne out by the fact that many of the latest boats are being fitted with other prime movers. Still, in view of the published performances of some of the Diesel-engined boats in the present war, as well as the known records of service of similarly-engined boats, one is forced to the conclusion that Mr. Hoar has been peculiarly unfortunate in his experiences with this class of engine. His explanation of the successful work accomplished by German submarines, viz., the fact that they work in relays, spending about a fortnight at sea and a similar time at their base, is obviously a stretching of this fact to cover possible engine defects, for on the showing of the author the time spent at the base is necessary for the recuperation of the crews after their spell on duty.

The future development of the submarine presents possibilities of a peculiarly interesting nature, not only on their own account, but also on account of the influence which such development may have on the composition of fleets and on the design of the units which comprise the modern battle fleet. It is known that the size, power and speed of submarines have increased enormously since the outbreak of the present war, but details of the latest developments are, of course, lacking. That there are limits to the useful development of the submarine considered as a torpedo-boat, or as a cargo carrier such as the Deutschland, is pointed out by Mr. Hoar, but there is much food for thought in the following sentence taken from his chapter on "Future Development:"—"The future will unquestionably bring forth a submarine capable of operating freely at great distances from her base, and combining to a certain extent the qualities of a surface cruiser and those of the under-water craft." This forecast is of interest as foreshadowing development in size, surface speed, radius of action and armament, and opens up a wide field of speculative development. The lack of speed and manœuvring power of large vessels in the submerged condition, and the consequent liability to attack and destruction by fast surface craft or by small handy submarines, sets a limit to development with the available submerged power plant. With a continuation of recent development it may be expected that the submarine of the immediate future will be quite able to hold its own in the matter of armament with light patrol boats and even the older classes of destroyers. Evidence of the increase in radius of action and of the use of powerful explosive charges in torpedoes is furnished by the work of the German submarines in their offensive exploits during the war. These successes also indicate the vast importance of increased radius of action in enabling the submarines to operate at widely distant points and thereby enormously increase the expanse of sea which must be patrolled in order to secure even a moderate degree of safety for merchant vessels.

Of the problems involved in the suggested developments by far the most important is that of propulsive power. For vessels employed as commerce destroyers the problem is fairly simple, for such vessels would simply lie in wait—probably in the surface condition—on the trade routes till their victims came in sight, when they would dive and move slowly to a position suitable for the discharge of their torpedoes. For such work high speed in the submerged condition is not necessary, and the case is met by the present arrangement whereby power is derived from storage batteries. The case of vessels intended to act in conjunction with the fleet is altogether different, for in their case a high surface speed to enable them to move with the fleet and a high submerged speed for manœuvring are essential to success, and for these qualities the present combination of Diesel engines and electric motors and storage batteries is not conspicuously successful, owing to the high weight of each power system per unit of power. Here the ideal is a single-power system for both surface and submerged drives, and experiments to this end have been and are being made. The weight of a steam installation would be considerably less than that of oil engines of the same power, and the saving thus gained would be available for increasing the power of the submerged driving installation. Mr. Hoar claims that a single-power system giving satisfactory results and showing an increased speed and radius of action in the submerged condition has been tried under the inspection of a United States Naval Board, but no particulars of this system are given in the volume under review.

No practical difficulties are to be anticipated in the hull construction due to increased size except those incidental to the closing of hull openings, should these be increased in size. The increase in size, together with the probable shipshape construction of the upper part of the vessel, should make for increased stability in the surface condition, and with turbine machinery the lower position of the centre of gravity of the machinery should improve the stability in the submerged condition.

The means of defence against submarine torpedo attack are of peculiar interest at present, and it is freely conceded by the highest authorities that no definite solution to the problem has yet been found. None the less, such means of defence as have been evolved have already given very satisfactory results, and may be depended upon to do even better. While a number of possible means of defence are discussed, no fresh light is thrown on the problem, and Mr. Hoar expresses his belief that the best means of defence lies in the provision of a sufficient number of high-speed patrol boats of small size and light draught and suitably armed with a light gun.

Chapters on "Tactical Evolutions of the Submarine" and "The Torpedo and Submarine Mines," the former dealing with the employment of the submarine in coast defence, raiding, and fleet actions, and the latter mainly descriptive of the origin and development of these weapons, complete the volume.

To those who have made any study of the subject of submarine navigation there is revealed little of novelty, but none the less the volume will prove of much interest and value to many who, at this time, are anxious to gain reliable information as to the design and construction of the modern submarine and its possibilities in the immediate future. The text is supplemented by a large number of excellent photographs and diagrams, which will be found of great service in conveying correct impressions of the different types and of the interior arrangements. The author is evidently of opinion that Britain has devoted too much time to the devising of means of defence and too little to the development of the submarine, but one reaches the end of his volume with a comfortable feeling that perhaps after all the British authorities knew what they were about, and with the profound conviction that our achievements in the matter of design and construction of this class of vessel will bring no discredit on our position as the premier Naval Power.

THE INSTITUTE OF MARINE ENGINEERS.—The annual meeting of this Institute will be held at the Minories, Tower-hill, London, E.C., on Friday, May 18, 1917, at 7 p.m. The president nominated by the council is Mr. Richard H. Green.

THE GERMAN 42-CM. HOWITZER.

We quote from the last issue of the *Journal of the United States Artillery* the following interesting notes on the chief features and methods of handling the German 42cm. Howitzers:—

These notes are the result of an accidental encounter with one of the 42-cm. howitzer batteries while on a visit of inspection to the 6th German Field Army, on the Arras section of the west front, between October 1 and 8, 1915. The battery was first met on the road at Henin-Lietard, near Lens, on October 1, where the officer in charge explained the system of transportation. On October 5 the battery was again inspected by special permission, this time on the road near Pont Maudit, when the loaded wagons were uncovered and a number of the details explained. On October 8 the battery was inspected in a firing position near Estevelles, while bombarding Loos, which had been taken by the English on September 25, during the recent great offence of the Allies.

Method of Transportation.—The battery consists of two pieces. Each piece with its carriage and manœuvring appliances is transported on five steel-framed carriages with built-up riveted steel wheels. Each carriage is of a special design to suit its load. Each wagon is drawn by a motor tractor, to which it is close-coupled by a yoke and coupling pin. The whole battery, therefore, comprises 10 units, each unit being made up of a wagon and motor. In addition, four other ordinary motor trucks of 4 or 5 tons capacity accompany the battery, carrying small parts, supplies, &c. Owing to the size of the units the battery takes up considerable road space and makes a formidable appearance. When inspected on the road, all wagons were covered with freshly-cut boughs, as a screen against aviators, and care was taken, when halted, to stop under the trees bordering Chaussee. The loaded wagons are normally covered closely with tarpaulins, so that nothing can be seen.

The wagons of each piece are numbered and designated as follow:—

No. 1 wagon, the appliance wagon, carries the material required in assembling the howitzer and carriage and for dismounting same.

The principal item of the load is the four-legged gin and winch, with block and tackle. The legs of the gin are hollow steel spars fitted with couplings. The appliance wagon also carries heavy steel anchor pins, snatch blocks, and certain parts of the carriage, such as elevating and traversing gear, loading cranes, &c.

No. 2 wagon, the platform wagon, carries a one-pieced steel-frame U-shaped platform, with two box-girder steel rails for hauling the carriage into place on the platform.

No. 3 wagon, the cradle and spade platform wagon, carries the howitzer cradle and a huge spade of special construction, to be described later.

No. 4 wagon, the carriage wagon, is the carriage proper of the piece, the hind wheels of the wagon constituting the carriage wheels as in a field gun, the front wheels of the wagon being used only for road transport and being uncoupled from the trail and replaced by the spade when the piece is mounted for firing.

No. 5 wagon, the howitzer wagon, carries the piece, which is supported in the grooved side rails of the wagon by projecting ribs on the side of the howitzer.

Motor Wagons.—The motor wagons attached to No. 1 are larger and more powerful than the others, having motors of 60 to 80 h.p., and being provided with a steel-cable drum slung under the chassis. This drum is driven by the engine and is used for the purpose of hauling the different wagons on and off the platform. The motor wagons attached to wagons 2, 3, 4 and 5 have engines of 40 to 50 h.p., and are of different systems and manufacture, with the avowed intentions of trying out the different types of motor tractors under service conditions. Among the manufacturers noted are Daimler, Benz, Pedens and Pohl. All motor tractors are essentially of the same type as developed in Germany for agricultural purposes. They all have cleated rear wheels about 8 ft. in diameter, with tyres 12 to 14 in. broad. In the Pohl system the rear wheels have, in addition to the cleats, a system of steel blades operated by an adjustable eccentric on the axle, and working through slits cut at right angles through the steel rim. By proper adjustment of the eccentric these steel blades can be set to project beyond the surface of the steel rim, and thus afford a better grip on the ground than is possible with the fixed cleats. This arrangement is similar to the feathering arrangement sometimes used on the paddle-wheels of steamers, and is stated to give increased adhesion, particularly on soft ground.

All engines on motor tractors are four-cylinder, water-cooled, with magnetic ignition, of simple but rugged construction. Transmission of power to the rear axle is by chain drive. Steering is effected through the medium of a quadrant and a chain, much the same as is used in heavy road rollers. One make of tractor had but one wheel on the front axle.

Assembling of the Piece and Carriage.—For convenience in assembling the piece and carriage in the firing position the various wagons of the battery are formed in column with the two No. 1 wagons at the head, followed by the two No. 2 wagons, then the two No. 3 wagons, and so on. When travelling on metalled or hard roads the wagons carrying parts of the carriage and the piece move on their ordinary wheels, which have smooth steel rims about 10 in. wide. When moving over soft ground, such as when leaving the road to move into a firing position, caterpiller rims or girdles are fastened to the front and rear wheels of the loaded wagons. These rims consist of 12 segments for the hind wheels, which are some 5 ft. 6 in. in diameter, and of eight segments for the front wheels, which are about 3 ft. 6 in. in diameter.

The position of the emplacements having been determined, and the caterpillar rims attached, the column is moved by the head to the designated position. Each No. 1 wagon moving to the emplacement of its piece is followed by the other wagons pertaining to that piece. No. 1 wagons are halted at the emplacements and, after erecting the gins and unloading their loads, are hauled aside. The motor tractors of the No. 1 wagons then take up their position a short distance in front of the emplacement, from which point they can haul the remaining wagons up on to the platforms by means of the cable drums. If the ground does not admit of a straight-line pull the tractors are located at any convenient point and the cable led around a snatch block to an anchorage.

No. 2 wagon is then hauled under the gin and the platform lifted clear by the gin, after which the wagon is hauled away and the platform lowered to the ground, previously levelled for this purpose. When the ground is firm no other preparations than the levelling are required. When the ground is soft various expedients can be employed, either excavating to a firmer foundation, filling in with broken stone, or laying of a grillage of planks. The steel platform is lowered upon the prepared surface, carefully levelled, and oriented in the general direction of the fire.

No. 3 wagon is then hauled on to the platform, using the steel box-rails for this purpose, and the spade unloaded and temporarily laid on the ground. The cradle is then hoisted clear and the wagon hauled away, leaving the cradle suspended from the gin. No. 4 wagon is then hauled on to the platform, with caterpillar wheels attached, and approximately centred on the platform. The cradle is then lowered into the carriage, the cradle trunnions resting in the trunnion beds. The front wheels of No. 4 wagon are then uncoupled from the wagon and removed.

No. 5 wagon is then hauled up, its side rails being brought into line with grooves on the inside of the cradle, and the howitzer pulled off, the machined ribs on the side of the barrel engaging in grooves in the cradle as they leave the grooved side rails of the wagon. The spade is then hauled into position and coupled to the trail of the carriage, the traversing and loading gears assembled leaving the piece ready for firing. The battery commander stated that under favourable conditions the battery could be set up for firing in three hours.

The Spade.—An interesting feature of the mount is the "sporn," or spade, which serves both to check recoil of the carriage and as a traversing rack for changing direction horizontally. It consists, essentially, of a huge segment of a circle of peculiar radial cross-section, being built up of steel plates and frames, measuring about 11 ft. on the chord. The radial cross-section measures about 5 ft. high and 6 ft. broad over all. The upper surface of the spade is in two levels, on the lower of which rests and slides the carriage-trail. In the vertical surface connecting the two upper levels lies a rack into which a pinion, fastened to the trail, engages. By operating the hand wheel on the pinion shaft, lateral motion is imparted to the trail. To the lower leg of the spade are bolted six blades, each approximately 2 ft. wide, which engage the ground and check the recoil of the carriage. If needed, a trench can be dug for the lower edge of the spade, and the back of the trench filled with broken stone or gravel well tramped into place to secure better resistance.

The Caterpillar Rim.—The caterpillar rim consists of a double row of shoes, the outer shoes being about 22 in. wide by 26 in. long and 2 in. thick, apparently of solid steel. The inner shoes are flanged so as to engage the wheel rim, and are hinged to the outer shoes at their middle. The slack of the girdle is such that at least two of the shoes lie flat on the ground, and but for a small sector of arc three shoes are on the ground. The arrangement therefore insures that the weight of the wheels is always distributed to the ground through at least two outer shoes, resulting in such a distribution of weight as to enable the wagons to be hauled over soft ground. In this connection the battery commander stated that the motor tractors with caterpillar wheels could haul their loads over considerable obstacles, such as deep road ruts, shallow side ditches, low banks, &c.

The Howitzer.—A more graceful and well-proportioned piece of ordnance could not well be imagined than the German 42-cm. gun. The bore between the lands measures exactly 42 cm., although the gun does not look so large. The thickness of the metal at the muzzle is surprisingly thin, not over 3½ in. by estimation. The length of the gun over all is exactly 5 m., determined by measurement. The diameter of the breech is about 4 ft. The fermeture is the well-known Krupp sliding block, and is completely opened or closed by three turns of the operating crank.

Personnel.—The personnel of the battery consists of 280 men, commanded by a captain. Of the men, 200 are foot artillerists and the remainder are chauffeurs and mechanicians, most of them from the shops of the several motor truck manufacturers and from the Krupp works. An ordnance expert from the Krupp works was attached to the battery as a Lieutenant of the Reserves. In the actual firing of the battery 25 artillerists were required at each piece.

Ammunition and Ranges.—The shell weighs about 820 kg., or about 1,800 lb. It is about 3½ or possibly 4 calibres long, and has the ordinary ogival head. The powder charge is contained in a large brass case about 18 in. high. The most effective range, namely the one giving the maximum accuracy, was stated to be 9,400 m. The maximum range is much greater, but no information would be given on this point. The ammunition is transported in a special motor truck column which was not encountered, and no details as to loads or number of wagons could be obtained.

Firing.—On October 8, 1915, this battery was observed while firing on the English position at Loos, for which purpose it had been emplaced in a quarry pit pertaining to a cement mill near Estevelles. The floor of the pit is about 18 ft. below the general surface of the ground, and is entered by a ramp with a slope of about 1 in 8. The howitzers were set up close to the almost perpendicular bank of the pit, about 150 ft. apart. On each side of each piece was a shell and powder store, formed by a slight excavation in the bank and covered by paulins.

In loading, the pieces are brought to a horizontal position. A shell is brought from the shell store on planks laid on the ground and placed under the loading crane, from which is suspended a shell tray. The shell is rolled on the tray and clamped in place, a brass case with the powder charge is set on the frame forming part of the tray, and the whole load hoisted by the crane, six men operating the hoisting crank located near the end of the tray, three on each end. The tray is centred in the breech and the shell pushed into the chamber. The rammer staff, which is comparatively short, has knotted ropes fastened to its rear end; these ropes are led forward and, with some dozen men manning the staff, the projectile is rammed into its seat, giving forth the clear metal ring that indicates good centring. While ramming, the men stand on the trail of the carriage and on the upper surface of the spade. The brass case containing the powder charge is then lifted from its frame and pushed into the powder chamber, after which the piece is elevated by the elevating crank in the front and traversed by the traversing gear in the trail. Sighting was, of course, indirect, the sighting point being a staff planted in the ground beyond the rear edge of the pit. Firing was by lanyard, the man pulling it sometimes standing on the ground and sometimes remaining astride of one cheek of the carriage and taking a short hold on the lanyard.

The recoil of the gun is about 4 ft., and it moved back and forth easily without jar. Careful observation of the spade failed to disclose any visible motion. As the battery was fired at ranges from 7,600 to 7,800 m. (8,311 to 8,530 yards) the elevation was considerable, apparently about 40 deg. The high elevation, as well as the firm stony ground of the quarry, were both favourable to checking horizontal motion. It should be stated here that the cradle has two recoil cylinders and two return cylinders, one each above and below, and surprisingly small for so powerful piece of ordnance. A slight splinter-proof steel shield is also attached to the front of the carriage.

Fire control was from captive balloons and possibly also from a land station as it was stated that fire was being observed from three points. After each shot the results were telephoned to each gun, there being a telephone station between the guns. The blast effects were considerable, but not disagreeable to observers standing on the edge of the quarry pit in rear and about 80 ft. from the guns. The roof coverings of the buildings of the cement mill, located about 150 ft. in front, were lifted and dislodged. The battery fired seven shots in 29½ minutes by actual timing, counting from the first shot. There was not a single hitch or delay with either piece, although this was the first time the battery had been fired in the field, it being entirely new and fresh from the Krupp works at Essen.

Weights.—The weights of the loaded wagons vary somewhat, but average about 15 tons. The motor tractors also vary, those of wagon No. 1 being the heaviest and also weighing about 15 tons. On fairly good and level roads the battery travels about 10 km. per hour.

YEAR-BOOK OF SCIENTIFIC AND LEARNED SOCIETIES.—We have received from Messrs. Charles Griffin and Co., Limited, Exeter-street, Strand, a copy of this year-book for 1916, the thirty-third annual edition, which they issue at 7*s.* 6*d.* net. It covers the scientific and learned societies of Great Britain and Ireland, and gives the names of the officers of each body, the dates of meeting, the fees, and the titles of the papers read during the session 1915–16.

THE AUTOMATIC CONTROL OF TRAINS.—In his report upon the collision which occurred on the London and North-Western Railway at Wigan, on December 19, between two passenger trains, Lieut.-Colonel E. Druitt stated that to prevent collisions under the conditions which obtained in that instance the only solution would appear to be the automatic control of trains, by which the brakes are applied when a signal is passed at danger. He considered that to do this effectively a full application of the brakes should be made if a stop signal were passed at danger, and it would be a further precaution on the side of safety in such cases if the driver were unable to release the brakes until the train had come to a standstill; but details of the necessary appliances could only be decided by actual experience. Colonel Druitt added that systems of automatic control have been under trial by several railway companies for some time, but the question presents many difficulties, for it is manifest that with so much inter-running of one company's engines over other companies' lines, any system, to be really effective, must be universal throughout the country, and it is possible that there may be more such inter-running in the future. Owing to existing conditions the matter has not progressed so quickly as it otherwise would have done, but it is to be hoped that it will be settled in due course. Similar remarks on the automatic control of trains were made by Col. J. W. Pringle, in his report upon a collision which occurred on the same day, at Kirtlebridge, on the Caledonian Railway.

THE NEED OF SAFETY VALVES ON HEATING BOILERS.

DURING the recent severe frost a large number of explosions of circulating boilers have occurred, in many cases resulting in loss of life and serious damage to property. With a view to drawing attention to the necessity of taking steps to prevent these so-called "accidents," the following particulars of an explosion which occurred on February 7 last on the premises of Mr. T. Halstead Sellen, rag, woollen and waste-paper merchant, Knowsley-street, Bury, may be instructive and of interest.

The boiler was of the ordinary circulating type used in connection with the heating apparatus on the premises named, and when the explosion occurred two women were warming themselves at the fire; one of them, Mary Ann Lomax, rag sorter, was killed, and the other severely injured.

At the inquest, conducted by Mr. S. F. Butcher, district coroner, Mr. Sellen, the owner of the boiler, was represented by Mr. J. Chapman, solicitor, Manchester, and Mr. H. J. Owner, H.M. Inspector of Factories, was also present. After the medical and other evidence had been taken James Braid deposed that he was foreman at the Knowsley-street mill, and had been employed in that capacity about three months. It was part of his duty to look after the heating apparatus, and during the whole of that period it had appeared to have worked satisfactorily. The boiler was used for heating purposes only. In reply to the coroner, witness said that he tested the pipes in the second room and at the inlet half, and they were warm. He also tested what was called the "expansion" pipe, but did not thoroughly understand what the pipe was for. About a quarter past 10 he heard a loud explosion, and found that the boiler had burst; he also ascertained that the deceased and another woman were missing, but they were found shortly afterwards and properly cared for. All the experience he had had was when he looked after another heating apparatus in the town; he had no knowledge whatever of the system of working the boiler, except just firing it up, and there was no valve or anything to warn him as to the necessity of keeping the pipes clear of obstruction so that the circulation might be complete. In reply to Mr. Owner (factory inspector) witness said that he tested the pipes by feeling them with his hands, and if they were warm he considered they were working all right.

Mr. Owner: Was there anything, either on the boiler itself or on the piping connected with it, whereby you could tell there was water in the boiler? Was there any gauge, stop-tap, safety valve, or anything of that kind?—No.

Mr. Owner: The only means by which you could tell whether it was working right or not was by the pipes?—Yes. No one gave me any instructions as to how to work the boiler when I commenced to look after it. No one had been to examine the boiler while he had been there. There was no pressure gauge on the boiler.

Mr. T. Halstead Sellen, The Nook, Birtles, near Bury, said he carried on the business of a paper merchant at the Knowsley-street mill. The boiler measured about 4 by 3 ft.; he did not know what it was made of until after the explosion. It had been working at his mill about five years, having previously been fixed at the Radcliffe Technical School. It had worked satisfactorily whilst he had had it, and had been used every winter. He had no knowledge personally of heating systems or of boilers. The pipes from the boiler were only used to heat the second storey. He had not tested them on the morning of the explosion. The noise when the boiler burst was like that of falling masonry. The boiler had been put in originally by Messrs. Bentley and Sons, of Bury, or their executors. It had not been insured, nor had it been recently inspected. Personally, he knew something of the method of feeding the boiler, but had no real knowledge of engineering matters, nor had anyone else about the place. When the boiler was put in he had no written or printed instructions with regard to working it, and as he put the matter into competent hands he naturally concluded that due provision had been made for a constant supply of water to the boiler.

Mr. James Bentley, Manchester-road, Bury, manager for the executors of Messrs. Joseph Bentley and Sons, sanitary engineers and plumbers, Fishpool, Bury, said he made an examination of the exploded boiler on February 12. It was a wrought-iron saddle boiler, made of plates $\frac{5}{16}$ in. thick, welded together, there being no seams. It was put in four years ago last December, and was a second-hand boiler, having been previously worked at the Radcliffe Technical School for six or seven years. When it was put in at Knowsley-street it was in splendid condition.

By the coroner: There was no safety valve attached to the boiler, and the only means of preventing undue pressure was the expansion pipe, which was an open-ended one. The boiler was fed from a cast-iron cistern in the top storey, and the diameter of the feed pipe was $\frac{1}{2}$ in. internal bore, the water entering at the bottom of the boiler. The hot water went out at the top by means of a 2-in. wrought-iron tube, internal diameter, returning to the place from which the boiler was fed.

Answering further questions, the witness said the expansion pipe was at the end of the outward journey, and was at the highest point, having an open end over the cistern. It was the ordinary domestic system of heating. The total length of pipe heated was 400 ft., but the boiler had a capacity of heating 1,200 ft. with 4-in. piping. On the Monday before the explosion he cut the main pipe close to the expansion pipe on the inner side, and water commenced to run out, and he saw small particles of ice going towards the boiler. The expansion pipe was clear at both ends. When he cut the pipe there was an indication that it had been choked by ice between the expansion pipe and the boiler. He next cut the 2-in. pipe at the further end away from the boiler, and found it completely solid with ice. He went to examine the place on the Thursday, and found the boiler demolished. He did not find anything more until the 12th.

The Coroner: Substantially, what it amounts to is that supposing there was choked-up ice or anything of that sort, the area of the boiler would be extended into the pipes, and there would be no relief except by the expansion pipe?—That is so.

And if choked between the boiler and the expansion pipe it simply became one large boiler?—That is so.

Would it not have been feasible to have fitted a steam escape valve or something of that kind?—It would.

Why was it not done?—There was no provision on the boiler, and it worked satisfactorily at the place it came from.

The Coroner: The same with a kitchen boiler?

Mr. Owner: No difference, only you have a good accumulation to get a supply from.

The Coroner: Do you consider the kitchen boiler system a satisfactory one where any other system could be utilised?—I do not.

You don't like the kitchen boiler system?—No, I don't.

The difficulty is to fix a safety valve on a kitchen boiler?—That is so.

Here there would not have been any difficulty at all?—No, except that it was not fitted for one.

You could have put one on, could you not?—We could.

Why did you not?—It always worked satisfactorily without.

It is a rotten, bad system, and why do you perpetuate it, when you know it is a bad system and can be avoided in cases like this?—No reply.

The Coroner (continuing): You men who are experts have to lead the way, and not we men who know nothing about it.

Answering the coroner's further observations, witness said there was an air-tap on the return pipe, and by opening that tap it could be ascertained whether circulation was going on.

The Coroner: Are you satisfied the explosion arose through the choking-up of the pipes by ice?—Yes.

Mr. Owner: Do you mean by that last answer that the boiler might have had ice in it?

It might have. I was satisfied the tubing was solid with ice practically down to the boiler, but I do not say there was ice in the boiler at the time of the explosion, but probably there was.

You would not have had much steam or pressure if there was ice in the boiler?—You might have had a little pressure in it.

Mr. Owner: We have evidence which contradicts that. Braid says on the morning of the accident he felt the pipes warm, and therefore concluded the circulation was working all right, so your opinion about having ice in the boiler could not be right?—No.

Mr. Owner: Neither could it be right about the outgoing pipes having ice in if what Braid says is correct.

When you examined it with me on the morning after the accident you found the expansion pipe solid with ice at the outlet end; that would mean that the whole pressure from the boiler was bottled up between the boiler and the expansion pipe without any relief?—Yes.

So that the small relief pipe could not act at the time of the accident?—Quite so.

Replying to further questions, witness said there was a test tap on to draw water off on the return journey. He did not think there was any difficulty in fitting a gauge-glass on that kind of boiler, and he thought it would be an advantage to have one when men did not know much about it. The tank was frozen over the morning after the accident. The boiler was not made to carry any pressure of steam.

The coroner, in summing up, said that there was not the slightest doubt that the woman who had unfortunately been killed had met her death through the explosion of the boiler, and what the jury had to determine was whether anyone was guilty of criminal neglect. He thought the witnesses Braid and Sellen were free from blame. It was admitted that the installation was not a satisfactory one. Either the plumbing industry was not sufficiently enlightened to see everything that might happen, or was accustomed to accept certain risks. It was unfortunate that the boiler had been installed and used as it had been. They all knew the dangers of domestic boilers, and he would have thought that experts skilled in that line would have said that such installations, where they could be avoided, should not be placed where people had to earn their daily bread. But the boiler was there, and he thought the jury would probably say that it was, looked at in retrospect, an error of judgment on the part of the people who put it in, but not gross negligence. If boilers of that description were going to be put in after the experience of this winter, there certainly would be a number of plumbers sent to take their trial for manslaughter, and a very good thing, too. He might as well speak plainly. It would be a very good thing if some plumbers were sent to take their trial for manslaughter if they put that kind of installation in when it could be avoided. He thought it would be a very good cure for a rotten system. Probably Mr. Bentley had followed the practice, but he did not think that the jury would find from the evidence what would justify them in sending him for trial.

The foreman (Mr. Mould) said he thought it was a case of accident, and that it was a piece of neglect.

A verdict of "Accidental death" was returned.

It will be seen from the evidence given above that this is another illustration of the necessity of fitting these circulating hot-water boilers with a small reliable deadweight safety valve. Years ago the opinion was too generally entertained that an explosion of a kitchen or a circulating boiler was caused by the stoppage of the pipes with ice, but that when the ice thawed, as it might with the presence of a fire, or change in the weather, the cold water rushed into what was supposed to be a red-hot boiler, with the result that the boiler rent, with disastrous results. It took a long time for the users of these boilers, householders and others, to be taught that explosions were caused, not by the contact of cold water with red-hot plates, but through the accumulation of pressure in the boiler due to the circulating pipes being choked with ice. In some cases very serious explosions have occurred during the summer months, and these were due to accumulation of pressure through the misuse of stop-taps. The great number of accidents that have occurred during the recent weeks of frost certainly shows the necessity of the dissemination of sound knowledge upon these matters, and it is surprising that so many people seem to be still ignorant of the fact that no boiler need burst if equipped with a reliable safety valve as already stated, and which can, as a rule, be readily applied and easily kept in good working order.

THE LATE MR. ALFRED EDWARD WHITE.—We regret to have to record the death, which occurred on Thursday, the 8th inst., at a nursing home in Bournemouth, of Mr. Alfred Edward White, late city engineer of Hull. Mr. White went to Hull as an assistant engineer in 1878; he was appointed city engineer in 1887, a position which he occupied until October, 1914, when he retired. He became a member of the Institution of Mechanical Engineers in 1882; an associate member of the Institution of Civil Engineers in 1881, and a full member of that Institution in 1895. During his period of activity in Hull Mr. White reconstructed the Victoria Pier and the ferry boat dock. Later, he built the sewage-pumping stations, the refuse destructor, the cattle market, several bridges, the East Hull baths, and the City and Evan Fraser Hospitals. The Hull tramway system is reckoned among his most important undertakings. Mr. White was 61 years of age.

NAVAL OFFICERS' WAR SERVICE.—There has been published in handy form, at the price of 1*s.* 6*d.* net, from the offices of "The Royal Navy List," 326, High Holborn, London, W.C. 1, a record of the naval war services of officers of the Navy, of the Naval Reserve, and of the Air Service, the Voluntary Reserve, and of the Royal Marines. From this it appears that 18 Victoria Crosses have so far been awarded to the Naval Service, including that to the boy Cornwall, to a seaman of the Reserve and to an able seaman of the Fleet. There is given, in alphabetical order, the war services of all officers, and these, it need scarcely be said, form a most interesting record, which will be welcomed by all interested in the Navy. Appended to the book is a diary of events of the war, so far as these have been participated in by the Navy. It may be added that such information is reproduced from "The Royal Navy List," which now constitutes a "Who's Who in the Navy," and is published annually at 10*s.*

WEIGHTS AND MEASURES (METRIC) BILL, 1917.—A Weights and Measures Bill, drafted by the Associated Chambers of Commerce, is now being circulated throughout the country for consideration and criticism. Although nothing of the kind has happened in any "metric" country, some British manufacturers fear that the compulsory adoption of the metric system in this country would necessarily involve the immediate scrapping of all their existing machines, patterns, tools and other workshop standards. It should therefore be known that to overcome this difficulty the following clause has been inserted in the Bill:—4 (*a*) "Provided that nothing in this Act shall affect the manufacture or use of any machinery, tool, pattern, sieve, template, or other article made by measures other than metric measures." The passing of an Act on the basis of the proposed Bill would thus mean that, while we should all be required to buy and sell in metric quantities, we should be at liberty to continue the use of our existing weights and measures for manufacturing purposes until such time as we ourselves chose to amend them.

BRITISH ENGINE BOILER AND ELECTRICAL INSURANCE COMPANY, LIMITED.—The annual meeting of the above company was held on the 9th inst., at the company's head office in Manchester, when Mr. R. Charles Longridge (chairman) announced that the results of the preceding year's operations had been most satisfactory, having regard to the conditions under which business had been carried on. There had been a marked growth in the number of firms insuring their plant against breakdown, with the result that the premium income had increased from 117,112*l.* to 125,851*l.*—the largest advance in any single year, with one exception, since the formation of the company. During the year, however, they had felt the effects of a noticeable increase in the cost of repairs and in the cost of travelling expenses; while, further, the company was cheerfully bearing the additional expenditure involved in making up to the men who were serving with the Forces the difference between their army pay and their salaries. The profit earned, nevertheless, showed only a small reduction from the previous year. The company was gratified by the honour conferred upon its chief engineer, Mr. Michael Longridge, M.A., M.I.C.E, M.I.M.E., who has been elected to the position of President of the Institution of Mechanical Engineers.

LOCOMOTIVES FOR THE PARIS AND ORLEANS RAILWAY.

WE illustrate on Plates XIX and XX, this week, one of a number of locomotives lately constructed by the North British Locomotive Company, Limited, of Glasgow, for the Paris and Orleans Railway. The engines have been built to designs and specifications supplied by the railway company, and are of the 4-6-0 type. The general design is well shown by the photograph, Fig. 1, reproduced on Plate XIX, while Figs. 2 and 3, on Plate XX, show end views, and Fig. 4, on the same plate, is a diagrammatic representation of the type, giving the leading dimensions, &c.

The engines are non-compound, and have outside cylinders 19½ in. in diameter, with 25⅝-in. stroke, fitted with piston valves having inside admission. By-pass valves are provided to establish communication between the two ends of the cylinders when the engine is running with steam shut off. These valves are operated by a cylinder fixed on the side of the smoke-box, a supply of steam from the main steam pipe closing the valves when the regulator is opened. When steam is shut off the by-pass valves are opened by the action of a heavy cast-iron weight fitted to a lever on the actuating shaft. Spring load relief valves are also fitted to the front and rear cylinder covers. The valve gear is of the Walschaert type, and its general design is seen clearly in Fig. 1. Screw-gear is provided for reversing.

The boiler is of the Belpaire pattern and made for a working pressure of 170 lb. per square inch. The boiler barrel is 4 ft. 11⅜ in. diameter inside the largest ring, and is 14 ft. 5½ in. long between tube plates. The fire-box casing is 9 ft. 10½ in. long, and the copper fire-box is fitted with a rocking grate having a rocking grate provided with a drop plate at the front end. The boiler is fed by two No. 10 Friedmann injectors, and is fitted with a Schmidt superheater, having twenty-one elements, and with two Coale safety valves.

The main frames of the engine are of steel plates and are of good depth, as seen in Fig. 4, which also shows the distribution of the wheels and their diameters. The brake system is of the Westinghouse type with a two-stage pump, and with brake blocks acting on all the coupled wheels, while there is also a counter-pressure brake on the Lambert Sander system. The engine is also fitted with a Hausshaelter speed indicator and one Detroit lubricator with five feeds. A heating system, using steam and compressed air, on the Lancrenon system is also provided.

For convenience of reference we subjoin a statement of the chief dimensions of these engines in both English and metric measures:—

	ft.	in.	mm.
Diameter of cylinders ...	0	19½	500
Stroke of pistons	0	25⅝	650
Diameter of coupled wheels	5	9⅝	1,760
,, bogie wheels...	2	9½	860
Wheel base, rigid	12	9⅛	3,900
,, ,, total ...	25	3⅛	7,700
	sq. ft.		sq. m.
Heating surface; tubes (inside)	1,274		118.5
Heating surface; fire-box	155		14.4
,, ,, total ...	1,429		132.9
Superheater surface (outside)	423		39.3
Total	1,852		172.2
Tractive force with 75 per cent. of boiler pressure in	lb.		kg.
cylinders	18,220		8,264
Weight in working order:—	tons	cwt.	tonnes.
On coupled wheels ...	48	16	49.5
Total	67	17	68.9
	ft.	in.	mm.
Gauge of railway	4	8½	1,440

TWIST DRILL GROOVING MACHINE.

WE illustrate on this page a simple but effective type of machine, recently introduced by Messrs. Isaac Best and Co., Limited, of Newton Heath, Manchester, for cutting the spiral grooves on twist drills. The machine can be adjusted, at will, either to cut these grooves of the same depth throughout, or to cut them to a depth which gradually diminishes from point to shank, or, as a third alternative, with parallel grooves for some distance from the point, thence gradually diminishing in depth as the shank of the drill is approached.

We show in Figs. 1 and 2 two patterns of the machine. The photograph, Fig. 1, represents a single-cutter machine for drills up to ½ in. diameter, whilst the line drawing, Fig. 2, shows a machine for large drills in which both grooves are cut simultaneously. Each machine embodies, however, the same general idea, though there are some modifications in detail. The blank to be cut is mounted in a chuck, which is shown in place in Fig. 1, but is omitted in Fig. 2. This chuck is given a screw motion of the required pitch by means of the quick pitch screw *a*, Fig. 2, which works through a nut clamped in a bracket bolted to the bedplate of the machine. Both screw and nut can be replaced by others when a different pitch is required. The cutter heads *b*, *b*, Fig. 2, are mounted in brackets, each of which is pivoted about the axis of the shaft carrying the driving pulley *c* and the gear wheel by which the drive is communicated to the cutter spindle. The level of this spindle above the bed of the machine can, therefore, be altered, without interfering with the drive, by swinging the bracket which carries it, and this motion is utilised for adjusting the depth of the cut. When a groove of variable depth is to be cut these brackets are gradually tilted as the work is advanced between the cutters, so that the distance between the two gradually opens out, thus leaving a thicker core as the shank of the blank is approached. This is effected by screws which act on arms *d*, *d* forming part of the swinging bracket. This adjusting screw is clearly visible in the view of the single-cutter machine, Fig. 1. Strong springs suitably disposed between the bracket and the bed keep the arms *c*, *c* in close contact with the adjusting screws. Levers *e*, *e* clamped to the shanks of the adjusting screws rotate these as the blank is advanced, being operated by the links *f*, *f*, which in their turn are connected to a sliding rod *g*. This rod is either carried forward by the main spindle of the machine on which the screw *a* is mounted, as in Fig. 2, or is operated by a cam, as in the arrangement illustrated in Fig. 1. A worm gear *h* drives the screw *a*, which, as already mentioned, feeds forward the blank. This worm gear is power-driven by the two pulleys *k*, *i*, either of which can be coupled to the worm by the dog clutch shown. A knockout gear releasing the clutch is provided, and a rapid reverse can then be obtained by engaging the clutch with the smaller of the two pulleys, which is driven by a crossed belt. In this reverse motion the links *e*, *e* remain behind, so the cutters make the return stroke whilst held clear of the work.

Adjustment for different pitches and angles of groove is effected by shifting the cutter heads on their bases. A snug in the bottom of the head fits into the groove *p*, whilst the corner *q* of the head casting bears against the guide shown. The curvature of this is such that, however the head is shifted, the cutter always lines up in proper relationship with the axis of the blank.

The makers state that they have supplied a large number of these machines, as repeat orders, to one of the principal firms of twist drill makers in the country, and that, owing to the simplicity of the design, an untrained girl can learn to run several of the machines after a very short tuition.

TWIST DRILL GROOVING MACHINE.

CONSTRUCTED BY MESSRS. ISAAC BEST AND CO., LTD., NEWTON HEATH, MANCHESTER.

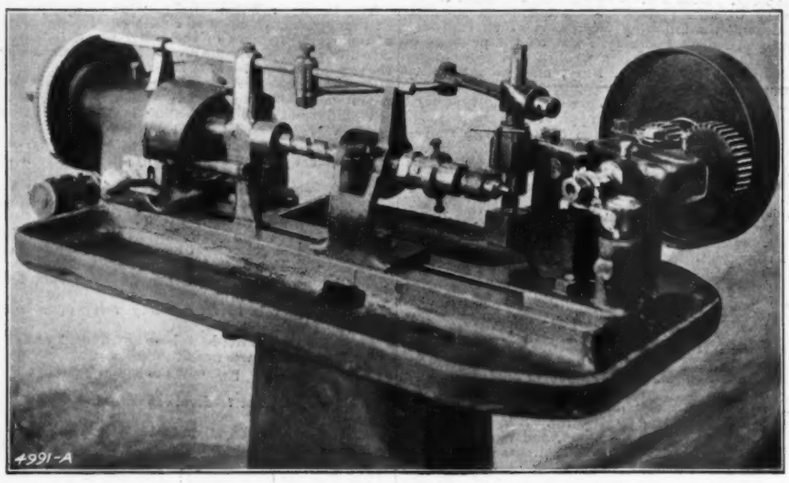


FIG. 1.

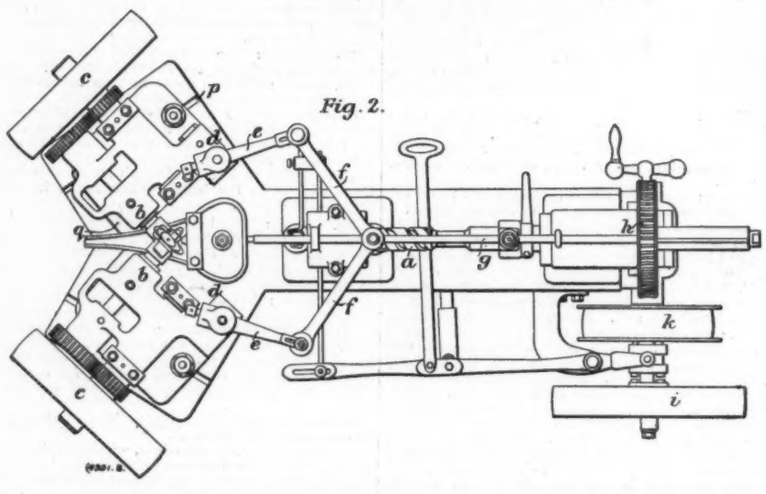


Fig. 2.

GIANT LOCOMOTIVE FOR THE VIRGINIAN RAILWAY.—A recent issue of the *Railway Mechanical Engineer* describes an engine built by the Baldwin Locomotive works for the Virginian Railway. This engine is a triple-articulated locomotive weighing 844,000 lb. and capable of exerting a tractive effort of 166,000 lb., and is intended to act as "pusher" engine, helping heavy trains up severe gradients. The engine has been designed to pass a loading gauge of 16 ft. 10 in. above rail-level, with an extreme width of 12 ft. at a height of 2 ft. 3 in. above the rail. The centre-line of the boiler is 10 ft. 9 in. above rail-level. The boiler is 8 ft. 4 in. in diameter and the tubes are 25 ft. long, and the heating surface is 8,120 sq. ft., with a grate area of 108 sq. ft. A mechanical stoker is provided. The engine has six cylinders, 34 in. in diameter by 32-in. stroke, arranged for compound working.

KINGSTON DOCK, GLASGOW; IMPROVEMENT AND RECONSTRUCTION.*

By MR. P. D. DONALD.

THE proposal to construct a tidal dock (known since as the Kingston Dock), in preference or in addition to riverside quayage, made fully 50 years ago, fixed the type of dock accommodation at Glasgow. The rise of tide at the time was 8 ft. 6 in.; it is now over 12 ft., so that the drawback as to the changing level of ships with the rise and fall of the tide is very considerably increased. Notwithstanding this, however, the probability is that, if the question of open or closed docks had to be decided afresh for Glasgow, the former would still be preferred. The harbour is 20 miles from the sea, with a comparatively narrow navigable channel intervening. If the entrance and exit of vessels to and from the docks were restricted to a limited period at and near high water, great congestion would be caused in the river channel, which is sufficiently crowded at times, even under present conditions, when vessels may enter or leave the docks at any state of the tide suitable for their draught.

The type of dock having been settled, tenders were invited for its construction with masonry walls at the entrance and timber wharfing for the inside quays; and, in June, 1864, the contract was placed with Mr. Manwell, who at that time did a good deal of work for the Clyde Trustees. The dock entrance was designed 60 ft. in width between the cope lines and with a depth of 14 ft. below the low-water level of the time. For the substructure of each side wall, as shown in section (Fig. 2, on Plate XXI), two rows of sheet piling, 11 in. thick by 35 ft. in length, were driven at the front and back of the wall, forming a long box averaging

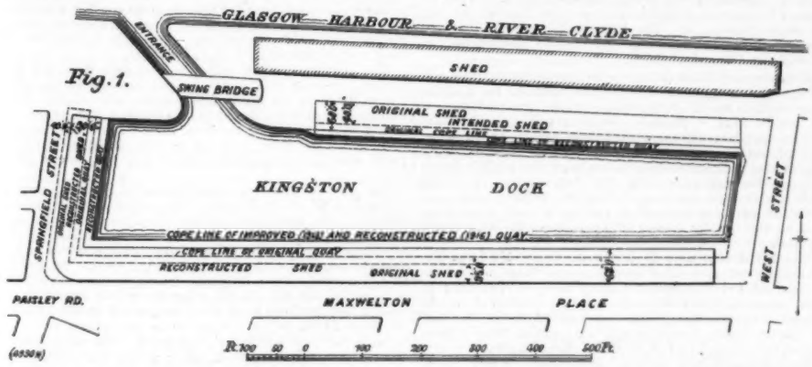


Fig. 1.

14½ ft. wide inside, and stiffened with cross divisions of sheet piling. The material within the two rows of sheet piling was removed by spooning to 16 ft. below low water, or 2 ft. lower than the intended depth of water in the entrance, and bearing piles, 11 in. square and 34 ft. long, with cut-off at 2 ft. above low water, were then driven in the excavated space, at 5 ft. centres longitudinally and 3 ft. 9 in. transversely. Thereafter the whole space was filled in with hydraulic concrete, lowered in boxes through the water. The concrete was composed of one part of Arden lime and one part of Kilbride cement, to one part of sand and three parts of whinstone metal. Cross and longitudinal sleepers were laid upon the tops of the bearing piles to carry the superstructure, which consisted of a facework of ashlar with backing of rubble, bedded and jointed in each case with mortar composed of one part of Arden lime to one part of sand and half-part of mine dust. The side walls were finished with a granite cope, 3 ft. 6 in. broad. At the east side wall special provision was made for the foundation of the swing bridge which spans the entrance (Fig. 1).

The inside quays were all of similar construction, and consisted of a wharf 21 ft. 10 in. broad, with three lines of supporting or main piles, 12 in. square. On the north quay the standard cope level of the harbour was adhered to, but at the south quay the proximity of Paisley-road at a high level necessitated the adoption of a cope level 2½ ft. above the normal. The east and west quays were finished with cope levels rising from the north to the south quay. On the south quay the main piles were 54, 44, and 42 ft. in length respectively, driven in transverse bays 5 ft. 4 in. apart between centres, the front piles with a batter of ½ in. per foot, and the others vertical. The piles were braced together with double joists at the top, and two lines of single horizontal bracings. At places where the wharfing required to be strengthened in later years, single, and in some cases double, diagonal bracings were added. The piles were tied longitudinally with three lines of walings under the joists and a stringer in front under the cope. The sheet piling, 11 in. thick and 35 ft. in length, was driven in line with the front main piles, with cut-off at 3 ft. above low water, and had a timber waling at back and a convex wrought-iron waling on front. The wharfing was tied back at intervals of 64 ft. by malleable-iron tie-rods, 2½ in. in diameter and 25 ft. long, one end bent round and fixed to the back main pile, and the other end passing through and screwed up on a bearing timber, 12 in. square, carried on a pair of stay piles 11 in. square and 30 ft. long. The surface of the wharf was formed with 5½-in. planking, covered with a ¼-in. layer of bitumen. The cope was in two pieces, each 10 in. deep by 18 in. broad, and was sheathed with plate-iron $\frac{7}{16}$-in. thick to prevent wear. Each front pile was provided with a 6-in. fender of American rock elm. The back of the wharf was lined for 14 ft. down from the top with close-jointed 4-in. planking spiked to piles; and to prevent floating debris being carried in under the wharf 3-in. planking, having 2-in. spaces between lines of planks, was fixed on the back of the front main piles. The sloping surface underneath the wharf was faced with whinstone pitching, laid to a slope of one in three on a bed of gravel 8 in. thick. At intervals of 32 ft. apart a pair of 12-in. square piles, 45 ft. in length, were driven in front of the centre row of main piles, to support the columns of the goods shed; and immediately in front of each pair a greenheart pile, 14 in. square and 45 ft. long, was put in to carry the cast-iron mooring pawl head.

The main and sheet piles, joists, and horizontal braces were of Quebec red pine, and the cope and walings of yellow pine. All this timber was creosoted with 8 lb. of creosote per cubic foot, in accordance with the practice already in operation on the Trustees' works for some years previous to this contract; and it is worthy of record that all the timber of the original wharf removed or cut into during the widening and reconstruction works to be described later was perfectly preserved, and indeed was, in many cases, better timber after 50 years than some of the new timber obtainable for the latter works.

The range of tide shown on the contract drawings is 9 ft., and the depth of water intended to be provided in the dock, and for which the wharves were designed, was 14 ft. below the average low water of the time. In June, 1867, a contract was placed with Messrs. P. and W. MacLellan for the erection of goods sheds on the north, south and west quays of the dock. The sheds were originally intended to be uniformly 40 ft. in width, but to allow of a sidewalk of 5 ft. being made along Paisley-road, the south quay shed was reduced to 35 ft. in width, as shown in section (Fig. 4, on Plate XXI). At the time of the opening the estimated total cost of the dock, including sheds, dredging and swing bridge, was given at 115,000*l.*, exclusive of land.

[The author here described the swing bridge, and referred to increase in harbour traffic and further dock construction.]

Towards the end of 1912, when the coasting trade was in need of additional accommodation in the harbour, the Trustees decided upon a scheme of improvement of the dock, consisting in a widening of the south quay, so as to provide for a new shed 60 ft. in length and to give 18 ft. of low-water depth in front of the quay—provision being also made for the same increased depth of water in the dock entrance. Fig. 1, on this page, is a plan showing the new work.

The work at the south quay (Fig. 5) consisted of a new timber wharf, 26 ft. in width, in front of the original one. As the old sheet piling was not sufficiently close-jointed to prevent the passage of fine material from behind the wharf, leading to subsidence of the surface, a new line of sheet piling, 10 in. thick and 40 ft. long, was driven, in bays of three piles, in front of the old sheeting, leaving a clear space 2 ft. in width and about 16½ ft. in depth, which was afterwards filled up with concrete. The concrete was deposited by means of an iron hopper-box specially made for the purpose, 10 ft. in length by 18 in. by 12 in., containing half a cubic yard. The chains keeping the bottom doors closed were released when the box was lowered by a crane to near the bottom of the space to be filled.

Along the face of the new sheeting a wrought-iron waling, 6 in. broad by 2 in. thick, was fixed with 1-in. bolts at every second pile. The sheeting was tied back at the iron waling by means of wrought-iron tie-rods, 2½ in. in diameter and 41 ft. long, spaced 13 ft. 4 in. apart, and anchored to concrete blocks 5 ft. by 6 ft. by 8 ft. long. The cut-off of the new sheeting was fixed at 1 ft. higher than that of the old sheeting, in order that these tie-rods should pass over the top of the latter. Each tie-rod was in two lengths joined together with a screw coupling, and was provided at the inner end with a cast-iron washer-plate, 2 ft. square, bearing on the concrete. After the trench for the anchor block had been excavated the back portion of the tie-rod was forced through the ground from the front, by blows from a wooden dolly suspended from a crane, the threads of the screwed end being protected by a specially made cap.

At the front of the new wharfing was a line of main piles, 12 in. square and 58 ft. long, driven at a batter of ½ in. per foot, about 26 ft. in front of the original front line and at 6 ft. 5 in. centres. Another line of piles, 56 ft. in length, was driven midway between the old and new front piles. The longitudinal distance apart of the new piles differed from that of the main piles of the original wharf, the space of 32 ft. being divided into five bays in one case and six bays in the other. At every 32 ft. the new main piles were in line with the old piles, the whole being bound together by double joists at the top and double diagonal braces. To form the back line of supports for the new wharfing at intermediate bays of new piles, 12-in. uprights about 20 ft. long were set up, embedded and grouted in the concrete filling between the two lines of sheet piling, and these uprights were similarly braced with the main piles. The piles were tied together longitudinally by five lines of 12-in. by 6-in. walings, and a stringer in front under the cope.

Between the front and middle piles and the middle and back piles or uprights two lines of struts were provided, the upper line, 12 in. by 9 in., at the level of high water, and the lower, 12 in. by 12 in., about 3½ ft. above low water. The latter, which butted on the sheet piling, were securely fixed to this and to the main piles by means of iron tail-bolts, straps and glands, so that they might serve as ties as well as struts. The end of the struts were supported by the longitudinal walings, or by cleats spiked to the piles.

Between the front piles were fitted two lines of dwangs, 12 in. by 9 in.; and each front pile was provided with a fender, 12 in. by 6 in. by 20 ft. long. The timbers forming the cope of old wharf were lifted and re-used, new timbers of the same size being put in where necessary, and the coping, when relaid, was sheathed with plate iron $\frac{5}{16}$-in. thick, bent to the required shape, and solidly bedded on and spiked to the timber. The decking of the original wharf was also made use of as far as possible in the new work. The seams and butt-joints were caulked, and the whole surface covered with bitumen, ¼-in. in thickness, and thereafter engine ashes were spread on top to the level suitable for the causewaying of the quay.

At distances of 32 ft. apart bearing piles, 56 ft. in length, were driven in the middle row of the main piles, to carry the front columns of the new shed. The existing water pipes and drains beneath the old wharf were carried forward to corresponding positions on the new wharf. The whole of the new timber was pitch pine, or Oregon pine specified to be grown in British Columbia. All the timber was creosoted with 8 lb. of creosote per cubic foot.

The effect of the widening of the south quay was not only to give greater depth in front, and to permit of a wider shed and increased quay space in front, but also to improve the slope or gradient from the public street at the back of the shed to the front of the quay, from 1 in 17 to 1 in 27; and this improvement was of very considerable benefit, as it enabled full loads to be removed by lorry, instead of the reduced loads that had to be worked with in the old shed.

As it was desired to carry the deeper water along the full length of the south quay, it was necessary to make provision for the greater depth at the south ends of the east and west quays also. At each of these quays a length of about 90 ft. of new sheet piling, similar to that at the south quay, was arranged to be driven in front of the existing sheeting. To keep vessels from catching on the projecting new piling, fenders, built out to beyond its face, were provided 10 ft. 8 in. apart, fastened by means of glands to the front main piles of the wharf.

The work at the dock entrance (Fig. 3) was similar to that described for the east and west quays—namely, a line of sheet piling 10 in. thick by 40 ft. long on each side of the entrance, tied by bolts 2 in. in diameter and 8 ft. long, grouted into the masonry superstructure of the side walls. Fenders similar to those described, 10 ft. apart on the straight and 5 ft. on the curves, were fixed on the face of the wall by batted straps; and along the top of these fenders a platform about 2 ft. in width was laid, with dwangs immediately beneath, fitted between the fenders, to prevent these being displaced by impact of a vessel.

The construction of the new wharfing at the south quay, with relative work at the east and west quays, as well as the work at the dock entrance, was done departmentally by the Trustees' workmen.

Contracts were placed in January, 1913, for the erection of a new goods shed on the south quay, including the dismantling of the old shed, and the work was begun in the same month. A commencement with the Trustees' work at the south quay was made in February, 1913, and by the end of that year the piling was finished for 600 ft., and the wharf completed for 550 ft.—that, is, about half the total length. The first section of the new shed, 352 ft. in length, was completed in November, and a portion of it, with the new wharf in front, was brought into use for traffic in the following month.

The work at the entrance was commenced in April, 1913, and completed in May, 1914. The operations at the south quay were still in progress, and by the middle of 1914 the whole of the old shed had been removed, and the new shed completed for a length of 512 ft., while the back wall and front columns and girders were erected for a further length of 320 ft.; the whole of the sheet and main piling on the east and south quays was completed, and the new south wharf entirely finished for a length of 966 ft.

Such was the state of matters when, on June 16, 1914, during a time of exceptionally dry and hot weather, fire broke out at the new works going on near the west end of the south quay. The conflagration spread with extraordinary rapidity eastward and westward; in less than 10 minutes the new shed, the nearest point of which was 256 ft. from the seat of the outbreak, was in flames.

* Paper (slightly abridged) read at the Institution of Engineers and Shipbuilders in Scotland, January 23, 1917.

The fire worked its way right round the dock in both directions until it reached the masonry work of the entrance walls. The quays and sheds, new and old, round the dock were totally destroyed; several schooners in the dock at the time were also burnt, and the men on board had narrow escapes with their lives, so quickly did the devastation spread, while the whole air was dense with the blinding and choking smoke from the burning creosoted timber.

The sheet piling was not damaged, but otherwise the new timber wharfing on the south quay was destroyed from the level of 4 ft. above low water upwards. The work done had cost about 32,000*l.*, and an expenditure of about 9,500*l.* had been incurred at the new shed and in causewaying. A very considerable proportion of this outlay was rendered useless by the disaster; but that represents only a portion of the total damage, including the destruction of the quays and sheds all round the dock, and the loss of harbour accommodation during the period of reconstruction. The improvement work done at the entrance, at a cost of 7,900*l.*, was not damaged.

The Trustees were now faced with the problem of the restoration of the dock; and after various proposals were considered it was decided to reconstruct with concrete walls, the substructure being formed with concrete deposited under water within lines of sheet piling. This decision was made largely on account of the fact that the lower portions of the new front and middle main piles at the south quay were intact, and could be worked in with new piling to form the face and back of the proposed concrete substructure.

The section adopted for the south quay (Fig. 6) includes a line of new timber sheeting, 10 in. thick and 35 ft. in length, driven in bays between the front main piles already in, and a line of temporary sheeting, 6 in. thick and 32 ft. in length, driven between the piles of the middle row, the inside distance between the lines of sheeting being 12½ ft. at the top and 14 ft. at the bottom of the substructure.

The cut-off of the front sheet piling is at 3 ft. above low water. Six inches below this level a wrought-iron waling, 6 in. by 2 in., convex on face, was bolted to the sheeting and timber waling behind, with a bolt at every second pile; and through this waling were fixed tie-rods, 2 in. in diameter and 24 ft. long, spaced 12 ft. 9 in. apart, the inner ends of which were secured to the line of new sheet piling driven before the fire. In order to get these tie-rods in place the concrete filling between the two lines of sheet piling at the front of the original wharf had to be cut out, for 3 ft. in depth by about 3 ft. in length, at each rod. After a tie-rod was in place, to prevent corrosion it was encased in fine concrete, 9 in. wide by 11 in. deep, giving a cover of 3½ in.

By means of temporary divisions made with 6-in. sheet piles, pockets of suitable length, for the most part 64 ft., were formed, which were excavated by grabs to the depth of 21 ft. below low water, and filled in with six to one concrete, deposited under water by means of wooden hopper boxes, 4 ft. square and 3 ft. deep, containing 1½ cubic yard. To improve the joints between successive lengths of the substructure a 12-in. recess, 5 ft. wide by 4 ft. deep, was formed in the centre of the wall at the advance end of each pocket, into which recess the concrete of the succeeding pocket keyed

On the top of the new front sheeting and substructure, at 3 ft. above low water, a granolithic string-course was laid. This course is 2 ft. 6 in. on the bed and 18 in. deep; the face is curved outwards, so that the front upper edge projects 6 in. beyond the face of the sheet piling. The string-course blocks were moulded in 6-ft. lengths; the curved face was formed with three to one granolithic concrete, 6 in. in thickness, put into the moulds at the same time as the ordinary concrete. The blocks had large grooves formed in the ends, and when laid in position were by this means keyed together with one-and-a-half to one cement mortar. Similar grooves were formed on the back of the blocks, to provide a better joint with the concrete backing. Moulded during the summer, the blocks remained in the moulds for two days only; they were then stripped, and carefully stacked until required, after having the face smoothed over.

From the string-course upward the superstructure was formed in seven to one concrete with a facing, 6 in. in thickness, of granolithic concrete. The front shuttering, 9-in. by 3-in. dressed white-pine battens in 20-ft. lengths, was carried on 12-in. by 6-in. uprights, 5 ft. apart, supported by cleats nailed to the face of the front sheet piling of substructure, and held in position at the top of the string-course by bolts with the inner ends turned down to catch the back of the string-course; the top ends of the uprights were held in place by light bracings from convenient parts of the old wharf. It was found that, when the full weight of the superstructure concrete was brought upon the shuttering, there was a tendency for the uprights to bulge out, and, to counteract this, uprights were trussed with an iron rod, 1¼ in. in diameter, bent to 8 in. out at the centre, and braced and unbraced uprights were set up alternately.

The superstructure was built in lengths of about 64 ft., and has a batter of ¾ in. per foot; the thickness of the wall, which at the top of the string-course is 10 ft., is reduced at the back by two steps of 21 in. and one of 18 in., so that at the underside of the cope it is 4 ft. The top bench at the back was formed at a suitable level below ground to carry the 6-in. water pipe which runs round the dock.

The facing of three to one granolithic concrete was brought up at the same time as the rest of the wall. Iron plates, from 8 to 10 ft. long by 12 in. deep and ¼ in. thick, with three hand grips, were used to divide temporarily the two classes of concrete. From time to time as required, keeping pace with the progress of the concrete, the plates were drawn up by the concrete workers on the wall; they were never left in sufficiently long for the concrete on either side to set, and in this way the finer concrete at the front made a perfectly close joint with the mass concrete behind. The plates were maintained at the distance of 6 in. from the shuttering by small wooden chocks, which were kept continuously in use.

The wall was finished with a concrete cope 3 ft. broad on the bed and 15 in. deep at the front, with the top front edge rounded to a radius of 3 in., and the bottom edge chamfered to suit a corresponding chamfer in the top edge of the superstructure face. The cope blocks were moulded in lengths of 4 ft. in a similar manner to the string-course blocks; the ends were well scabbled for jointing, and had also provision for 6-in. iron dowels, grouted in place between the blocks. The front face and top surface had a facing of granolithic concrete, 6 in. and 4 in. thick respectively, and, to provide a better foothold, the top surface was roller-dabbed.

The mooring pawls provided in the reconstructed quay were designed for the new wharfing forming the widening of the south quay; the front part of the base of the casting fitted over and was bolted to the timber cope, while the back portion rested on the deck planking and was secured by five 1¼-in. bolts to the deck joists. The pawl castings were salved after the fire and were used in the reconstruction, being set in line with the front of the cope and fixed to the wall by means of 1¼-in. bolts and bent rails built into the concrete. The pawls are spaced 48 ft. apart, every alternate one being opposite a shed column. The moulded cope blocks were laid to within a short distance of the casting on each side, and the gap was filled in *in situ*, the concrete being well packed into the portion of the casting originally intended to receive the timber coping of wharf.

In addition to the tie-rods through the front piling of substructure, the superstructure of the wall was tied back by means of old permanent-way rails, placed at 12 ft. 9 in. centres midway between the tie-rods, having the ends turned, and the back end grouted into the concrete filling between the two lines of sheet piling at the front of the old wharf.

At distances of 32 ft. apart between centres concrete piers, 4 ft. by 3 ft., were corbelled out from the back of the quay wall, to form a foundation for the steel columns of the goods shed. Midway between the column seats timber uprights, 12 in. square and about 18 ft. long, were placed in position, resting upon the bottom back step of the superstructure, to support the timber beam carrying the cast-iron rails for shed doors. To keep these uprights in position during the refilling and consolidation of material behind the quay wall they were fixed at the top by means of 1¼-in. tie-bolts batted into the wall.

Fire-clay drains were laid to take the water from the down-pipes at each shed column, and these were connected and led through the quay wall at distances of 64 ft. apart, at the level of 2 ft. above high water. At suitable intervals the drains were carried to the back of the goods shed, being supported across the refilled ground by means of 12-in. logs, 38 ft. in length.

The reconstruction of the south quay, 1,085 ft. in length, has been described in detail, as it is typical, generally, of what was done at the other quays, the differences being chiefly in the substructure. As in the original wharf, the cope level of the south quay is at a high level, being 2 ft. 3 in. above the general height of quays in the harbour; this higher level is also carried along the west quay, with a fall of 1 ft. in the northmost 11 yards to the north-west quay, which, again, has a fall eastward of 1 foot. The north quay, east of the dock entrance, is at the normal level, and the cope on the east quay rises uniformly from this to the level of the south quay.

On the short north-west quay, 93 ft. in length, where the reconstruction after the fire was commenced, the work done in connection with the strengthening of the entrance was continued by the extension of the line of new sheet piling, 10 in. thick by 40 ft. long, driven about 3 ft. in front of the original sheeting. This piling has a cut-off at 7 ft. above low water; it is tied to the back piles of the original wharf by means of 2-in. tie-rods placed 11 ft. apart. The space between the lines of sheeting was filled in with concrete, to the depth of from 10 ft. to 12 ft. below low water. To carry the back of the quay wall, bearing piles, 12 in. square by 35 ft. long, were driven at about 6 ft. centres, 5 ft. behind the old sheet piling, with a cut-off at 6 ft. above low water; and the wall was founded on these piles at a level of 3 ft. above low water.

At the west quay, 213 ft. in length, advantage was taken of the reconstruction to provide for a goods shed 50 ft. in width in place of 40 ft., and also for a much-needed widening of Springfield-lane, now called Springfield-street, from 30 to 40 ft. The front of the quay was accordingly brought forward 21 ft. into the dock, an additional width of 1 foot being given between the cope line and front of the shed. The effect of this, and of constructing the quay wall with a higher cope level, as already mentioned, was to reduce by a half the surface inclination through the shed, from the street to the front of the quay.

To support the staging for the piling machine which drove the sheet piling forming the front of the substructure, temporary piles, 12 in. square by 30 ft. long, were driven 12 ft. apart and 18 ft. out from the old wharf, by a piling machine and frame mounted on a punt. The front sheet-piling, similar to that on the south quay, with cut-off at 3 ft. above low water, was tied back, through the iron wale, by tie-rods, 2 in. in diameter, 23 ft. long, and 8 ft. apart, bolted through a 12-in. by 12-in. beam fixed at the back of the sheet piling of the old wharf (Fig. 7).

In this quay the back of the substructure was formed by Ransome steel piles, standard D-section, 36 ft. in length, driven 14 ft. behind the inner face of the front timber piling, and afterwards drawn by steps as successive layers of the concrete filling became sufficiently set to permit of this being done. For the drawing of these, and of other temporary piling, a 10-cwt. Ransome pile extractor* was used with great advantage throughout the course of the work. The extractor was suspended from the hook of a 10-ton crane in the position required; and steam at 90 lb. pressure was supplied from a vertical boiler mounted on a punt, which could be taken to any point in the dock as required. This punt also carried an air-compressing plant, which furnished power for working the augers by which all timber boring for the bolts, &c., was done. Heads of piles, old and new, were also cut by this means, and afterwards adzed level, and this method proved very expeditious and of great advantage considering that this operation had to be done by tide work at a low level.

The substructure was constructed in seven pockets averaging 30 ft. in length, the divisions being formed with 6-in. temporary sheet piling. The superstructure was formed as described for the south quay, in lengths of about 60 ft., with concrete piers for shed columns, and uprights for supporting beams carrying rails for shed doors.

The west quay has a travelling crane upon it, and the front rail for this rests on the concrete cope, and the back rail on a beam supported by uprights, 8 ft. long and 8 ft. apart, resting upon a scarcement of the superstructure.

At the north quay, in order to provide for a goods shed 50 ft. in place of 40 ft. in width, the new cope line was brought forward 10 ft. into the dock. The length of quay on the new line is 762 ft.

For the piling-machine staging, as at the west quay, temporary piles 12 in. square and 40 ft. long were driven, 10 ft. apart, by floating piling apparatus. Special provision had also to be made for supporting the front line of the crane road, and for this purpose similar temporary piles were driven 15 ft. apart, and tom-shores set up midway between, carried on sole-plates resting on the back row of the piles of the old wharf.

The new front sheet piling in this case was tied back by 2-in. tie-rods, 8 ft. apart, bolted through 12-in. square beams fixed on the back of the centre piles of the wharf. The superstructure, founded at a level of 2 ft. above low water, was widened at the foot, for 5 ft. in depth, so as to embrace these piles, and by means of old rails spaced 10 ft. 8 in. apart it was also tied to the back row of wharf piles.

The substructure was constructed in pockets, averaging about 45 ft. in length. In excavating the first of these, at the west end, it was found that the old sheet piling was so open-jointed that the fine material was freely running into the pocket from behind, which caused subsidences and endangered the crane road. To obviate this Ransome steel piling was driven as close as possible in front of the old sheeting for the whole length of the quay; the pockets were then excavated to the required depth of 21 ft. below low water in the centre, and filled in with concrete to the original level of the dock bottom before excavation started, after which the steel piling was drawn, and the concrete filled in between the two lines of timber piling.

To permit of the excavation being done for the widened superstructure without interfering with the crane road at the back, it was necessary to drive a line of temporary sheet piling, 4 in. thick, to form the back of the superstructure. After the excavation was completed and concrete filled in to the depth of 5 ft., up to the first scarcement, this piling was drawn for use again.

The material met with in the excavation of the pockets round the dock consisted, for the greater part, of muddy sand. The removal of this material was done without difficulty by round diggers worked by 10-ton steam derrick cranes. The material was deposited in the dock, and afterwards lifted by dredger at the same time as the dock deepening was being carried out.

At the north-east corner of the dock, however, material of a different character was met with, which occasioned some trouble and necessitated special design in the substructure of the quay wall at this place. For about 100 ft. from the east end of the north quay, and about half that distance along the east quay, the presence of a bed of brick clay had led to forward movements of the original wharf, which had called for strengthening in 1885, and again in 1903, by means of tie-rods, one of which was carried right through to the riverside quay. The wharf piles on the north quay had moved forward at the top as much as 2 ft. 6 in. at one point.

On the opposite side of the river the presence of the same substrata had caused the failure of the original quay and several reconstructions of the same between Robertson-street and York-street, and led to the adoption there in 1902 of a foundation of caissons sunk under air pressure. The strengthening of the substructure at the east end of the north quay of Kingston Dock (Fig. 8) consisted in the formation of pockets behind, as well as in front of the old sheet piling. The pockets were constructed by driving a line of piling about 20 ft. behind the new front sheeting. For 57 ft. this back sheeting was of timber, 10 in. thick by 36 ft. long, which was left in after the concrete was deposited; the remainder of the length, 58 ft., was done with Ransome steel piling, afterwards drawn.

The work was carried out in much shorter pockets than elsewhere in the reconstruction, the lengths ranging from 12 ft. to 21 ft. The cross divisions were made with temporary 6-in. timber sheeting, with sometimes a line of steel piling in addition. The back portions of the pockets, behind the old sheet piling, were excavated and filled before the front portion so as to make secure the ground behind. The rear pockets were excavated to

* See ENGINEERING, vol. cii, page 198.

about 20 ft. below low water, or 1 foot less depth than the standard round the dock.

A square digger with teeth was used in excavating the pockets under water, but difficulty was experienced in getting the clay out of the corners, which could not be reached by the digger. The clay also adhered to the piling, especially in the bosom of the steel sheeting. At the places mentioned it had to be scraped down by iron rods and long spades, and a special scraper for this purpose was made by attaching a steel plate to a piling hammer which was worked up and down the face of the piling, by which means the clay was broken up by the cutting edge of the plate and carried down into the bottom of the pocket. Two of the back pockets, which were wholly in clay, were pumped out and the corners and sides cleaned by hand labour in the dry.

The front pockets were taken out to the depth of from 22 to 23 ft. below low water—that is, from 1 to 2 ft. lower than the normal depth.

The old sheet piling, the top of which was 7 ft. above present low water, was cut down in sections to 1 foot above low water, and above this level the concrete was put in place simultaneously in the back and front pockets, in order to obtain continuity in the full thickness of the wall. Old permanent-way rails were also laid in, with turned ends, to tie together at the top the two portions of the substructure.

The east quay of the dock, 167 ft. in length, is still under construction, but is approaching completion. Previous to the fire, as already mentioned, new sheet piling was driven along the front of this quay for about 70 ft. from the new south end, and the space between the old and new piling filled in with concrete.

For the reconstruction it was decided to form the substructure in pockets about 30 ft. in length behind the old sheet piling by driving a line of sheeting between the centre and back main piles of the old wharf. For 38 ft. this consisted of 10-in. timber piling, left in the ground; for the remainder of the quay the Ransome steel piles were used, being drawn and re-driven. As the section of piling was, however, not designed to sustain the pressure brought upon it in this position, the piles intended to be driven here were strengthened by having a flat-bottomed rail, weighing 60 lbs. per yard, riveted to each pile.

The hardest pile-driving in the whole work was encountered at the southern portion of this quay, due to the fine compact sand in which the driving had to be done. One or two attempts to drive timber piles to form the south end of the southmost pocket were unsuccessful, and ultimately this was done by steel sheeting driven with the help of a water jet. The water used was from the ordinary supply pipe, led by flexible hose to a wrought-iron pipe in the bosom of the pile, which was worked down into the sand just in advance of the pile bottom. The introduction of the water jet proved most effective, and occasionally a steel pile would sink considerable distances with the weight of the piling hammer simply resting upon it.

The lines of old and new sheet piling in front had cut-offs at 6 and 7 ft. respectively above present low water, and in order that this quay should correspond with the others, both lines of piling, with the concrete between, were reduced to the level of 3 ft. above low water, to receive the granolithic string-course. The wrought-iron walings at the original high level were taken off and refixed 8 in. below the new cut-off; and 2-in. tie-rods were put in, 12 ft. apart, tying the front piling to the back of the substructure. Five 2½-in. tie-rods put in for the 10-in. sheeting driven in 1913 were disconnected, and made use of for tying back the superstructure.

New 10-in. sheet piling, 35 ft. in length, was driven along the front of the quay in continuation of the 70 ft. already driven, and this work was completed during last month. In order to provide for the extra width of the substructure required by the nature of the substrata at the north end, the line of the new front sheeting was curved outwards towards the dock, on a radius of 750 ft., so that at the north end the new piling is about 8 ft. in front of the old.

The pockets on this quay were excavated to about 19 ft. below low water. During the progress of digging below the level of the ground in which the new front sheeting was driven the material in the space between the lines of sheeting ran into the pockets through the joints in the old sheet piling, and in this way the space was lowered to 15 ft. below low water. For about 40 ft. at the north end of the quay, where the space widens out, it will be possible to get greater depths by digging with small grabs.

After the reconstruction of the quays had made some progress the restoration of the goods sheds, which was done by contract, was put in hand. Work was commenced at the west shed in May, 1915; by the end of October this shed was completed, with the exception of the curved south-west corner. The laying of the causeway in the shed and on the quay was in progress also, and the new quay and shed were occupied for the first time on November 11, 1915, by the steamship Jacinth, bringing in a cargo of cement. The western berth of the south quay and the west section of the shed were brought into use on February 26, 1916; the centre section of the quay and shed in April, and the east section on November 23, 1916.

Owing to the present war conditions, and the difficulty and great cost of getting structural steelwork carried out, the re-erection of the shed on the north quay has been postponed. This quay is being completed with causeway as an open quay, and it has already been brought into use for the discharge of cargoes for which such a quay is suitable.

The estimated cost, when completed, of the reconstruction of the quays subsequent to the fire is about 70,000*l.*, including the special work at the north-east corner of the dock. The work was done during the war period, with the prices of timber and building material and the rates of labour greatly above the standard of pre-war times. Since the middle of last year difficulty has been experienced in getting and keping a labour force, and the progress of the reconstruction has suffered in consequence.

The extent of the work subsequent to the fire may be expressed by stating that the permanent sheet piling aggregates over 63,500 cub. feet of timber; the excavation under low water amounts to 13,500 cub. yards; concrete in substructure to 25,600 cub. yards, and concrete in the superstructure to 15,700 cub. yards. The number of men employed reached a maximum of 140, and averaged about 90.

Provided with new quayage and greatly increased and improved shed accommodation, and having an ample depth of water for the class of vessel that can be dealt with, there is every reason to hope and expect that Kingston Dock, so convenient to the city, will in this, the jubilee year of its first opening, enter upon a new lease of life and prosperity, and in the future provide a return commensurate with the relatively very considerable expenditure which the Trustees have had to expend upon its reconstruction.

The dock was originally constructed to the plans of Mr. Andrew Duncan, engineer of the Clyde Navigation at the time; the improvement and reconstruction works were designed by Mr. W. M. Alston, the present engineer.

In supplement to the plan and sections referred to in the paper we give on Plate XXII four perspective views illustrating the progress of the work.

Fig. 9 is a view showing the west quay and north-west quay complete, and work going on on the south quay—the driving of the temporary sheet piling to form the back of the substructure. The burnt and charred upper portions of the timber wharf had been cut away, and the engraving shows what was left intact of this timber structure after the fire.

Fig. 10 is a view of the west end of the dock already well completed, the concrete superstructure of the south quay being shown in the foreground. The machine in front is the Ransome concrete mixer, which was placed at such a level that the concrete ingredients could be tipped into the hopper from the level of the quay.

Fig. 11 is a view of the north quay in various stages of completion. At the west end the concrete superstructure is shown, and in the foreground one of the pockets is being excavated by the grab, which is shown hanging from the 10-ton crane on the right. This engraving shows the large amount of timbering which was required on this quay to carry the crane road.

Fig. 12 shows the reconstruction of the south quay in progress. The substructure of the pocket in the foreground has been completed, and the string-course blocks laid. Behind that work is in progress on the superstructure. The view shows the method of carrying the shuttering of this portion of the work.

SHIPPING ACCOMMODATION IN THE PACIFIC.—Arrangements have been completed, says the *Panama Canal Record*, for the construction of a floating dry dock at Vancouver, British Columbia, to be capable of handling ships of 18,000 tons. A new dry dock has recently been put in service at Prince Rupert, British Columbia. Its first large ship was the Orbita, which is 550 ft. in length and 67 ft. 3 in. beam. There is, besides, the 1000-ft. dock at Balboa, which is capable of handling the largest ships afloat, and is said to be the third in size among the dry docks of the world, the two which are longer being one in England and one under construction at Boston, MASS.

ELECTRO-METALLURGY IN THE UNITED STATES, 1916.—In view of the heavy demand for alloy-steels, formerly made in crucibles, and of ferro-alloys, and of the difficulties of importing aluminium and magnesium, it is not astonishing that the electro-metallurgical industry of the United States can look back upon an extraordinarily active year. Electric steel furnaces, practically doubled in 1915, progressed at the same rate in 1916, and the chief trouble is to find experienced workers. High-speed tool steel, formerly poured from 100-lb. crucibles, is now made in 6-ton electric furnaces. Ferro-manganese is being melted in electric furnaces; three new ferro-silicon works were opened during the year; one carbide plant of Niagara Falls has taken up this branch. Ferro-titanium is produced in the same place, and there is much demand for ferro-molybdenum, probably for gun-linings; ferro-uranium is a new electric-furnace product. The raw materials for most of these ferro-metals can be obtained in the United States; the output of chromite ore in California would not have been able to keep pace with the demand for ferro-chrome, however, if there had not been large stocks of chromite. The article in the January number of *Metallurgical and Chemical Engineering*, from which we take these particulars, also mentions that the electric steel production of Germany averaged 17,000 tons per month last August, whilst there had not been any new crucible-steel plants. As regards aluminium, the North Carolina plant of the Southern Aluminium Company passed into the hands of the American Aluminium Company and was shortly to restart operations. Electrolytic zinc seems to have more chances than the smelting of zinc ores in electric furnaces. The Anaconda Copper Company is making 100 tons of electrolytic zinc daily at Great Falls, and the General Electric Company is erecting an electrolytic zinc plant at the Mammoth Smelter in California. The electrolytic copper companies have more than recovered from the shock that the outbreak of the war gave them. Electrolytic refining of tin seems to have become a success in the American Smelting and Refining Company at Perth Amboy.

COLONIAL AND FOREIGN ENGINEERING PROJECTS.

WE give below a few data on several colonial and foreign engineering projects, taken from the *Board of Trade Journal*. Further information on these projects can be obtained from the Commercial Intelligence Branch, Board of Trade, 73, Basinghall-street, London, E.C. 2.

Australia.—The Sydney Office of H.M. Trade Commissioner in Australia reports that the New South Wales Public Works Committee, in a report recently presented to the State Parliament, has recommended the installation of a sewerage system to serve an area of 12,282 acres, having a population of 308,000, in the south-eastern suburbs of Sydney. The estimated cost of the works is 1,240,000*l.* The committee suggests that operations be commenced immediately by the installation of the system to such an extent as would serve about 900 acres, at an estimated cost of 312,000*l.* The name of the official under whose supervision the proposed works will be carried out may be obtained by United Kingdom manufacturers on application to the Department of Commercial Intelligence, The reference number (109) should be quoted.

Egypt.—The Egyptian *Journal Officiel* publishes a notice regarding the sale, by order of the Officer Commanding-in-Chief H.M. Forces in Egypt, of designs for light railway construction, consisting principally of wagons, railway points, turning tables, locomotives, &c. This property is that of an enemy firm in liquidation, Orenstein and Koppel—Arthur Koppel (Egypt), Limited. This firm, it is stated, had practically the monopoly of light railway construction in Egypt; the designs now offered represent the various types of wagons, &c., in use in that country, and are the result of years of study and experience. Offers for the purchase of this property will be received up to April 15, by Mr. F. H. Russell, the Receiver of the above-mentioned firm, at Gresham House, Sharia Suliman Pasha, Cairo, or at Palmerston House, Old Broad-street, London, E.C. 2. All offers must be accompanied by a deposit in cash equal to one-tenth of the price offered. Further information may be obtained at the offices of the Receiver in Cairo and in London.

Republic of Colombia.—The *Diaro Oficial*, Bogotá, publishes a law (No. 79 of 1916) authorising the Colombian Government to contract a loan of up to 15,000,000 pesos gold (about 3,000,000*l.* at par), to be devoted to port improvement works in the Republic and to other public works, &c., of urgent importance.

A DANGEROUS WOOL OIL.—A note on a dangerous oil, used in a woollen mill, was brought before the Yorkshire section of the Society of Chemical Industry at Leeds, last January, by Messrs. T. Fairley and B. A. Burrell. White wool oiled in the usual manner began to heat; the fact was fortunately noticed before the wool actually fired. On analysis the oil proved to consists of about 88 per cent. of fatty acids and 12 per cent. of neutral oil; there was a decidedly fishy smell, and the presence of insoluble bromides also pointed to fish origin; the oil lost 66 per cent. on heating to 340 deg. F., which is quite an unusual volatility, and had a flash point (open test) of 368 deg. F. Glycerin being wanted for other purposes, fish oils (largely fatty acids) find various application, but their use as wool oils seems decidedly dangerous.

THE EYE AND CONTRASTS IN BRIGHTNESS.—Lecturing upon the "Effect on the Eye of Varying Degrees of Brightness and Contrast" before the Illuminating Engineering Society on February 20, Dr. James Kerr, of the Public Health Department of the London County Council, referred to some effects which may be surprising. Having to examine long lists of figures in black type, he tried to facilitate his task by drawing vertical and horizontal lines in red ink, but the different focusing of the black and red strained his eye and gave him a headache, which did not trouble him when all the figures and lines were either black or red. That advertisements with letters in different colours are trying will have occurred to some of our readers. Dr. Kerr also questions whether a target is more distinct when a brilliantly illuminated white disc appears on a dead black background than when the surroundings were diffusely illuminated, and he does not recommend keeping a theatre quite dark while the stage is intensely illuminated; the contrast might be too glaring. While a flicker is notoriously trying, perfect uniformity of illumination may also fatigue the eye.

JAPANESE COMMERCIAL AND INDUSTRIAL COMMISSIONERS.—We read in *The London and China Telegraph* that the Japanese Government has decided to create the office of Commercial and Industrial Commissioners in the Foreign Office. These commissioners will be stationed at various important cities and towns in foreign countries and engage in investigations mainly into commercial and industrial conditions in the countries where they are stationed, with a view to furnishing Japanese commercial and industrial circles with knowledge and information concerning commerce and industry, making tours of inspection to various districts in case of necessity. To begin with, five commissioners will be appointed with the opening of the new fiscal year, commencing April next, and will be stationed at London, New York, Shanghai, South America, and in the South Sea Islands. The commissioners will be appointed from among able men in commercial and industrial circles, as their function is purely commercial and industrial, having no connection with diplomatic or political affairs. The former commercial commissioners had been attached to the Department of Commerce and Agriculture.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACT OF 1907.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the Communicators are given in italics.

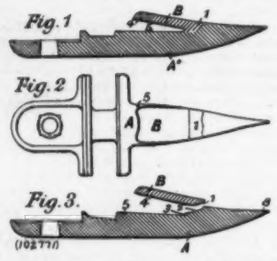
Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 6d.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any grounds mentioned in the Act.

AGRICULTURAL APPLIANCES.

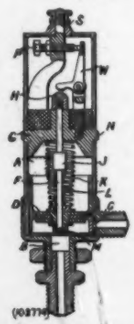
102,771. J. Bamford and C. J. Bamford, Uttoxeter. Mowing Machine Fingers. (4 *Figs.*) March 6, 1916. This invention has reference to mowing machine fingers of that kind which are made as steel drop stampings. According to this invention, the mowing machine finger is made as two separate drop stampings, marked respectively A and B (Fig. 3), the stamping A corresponding with the whole of the finger except the top jaw B and its base part 1, and the other stamping B consisting of the top jaw, which at its root is made with a flat or other convenient form of base 1 adapted to fit on to a similarly shaped



part 2 of the main stamping A between the bottom 3 of the jaw and the point 8 of the finger, and at this part 2 the top jaw B and the main stamping A are welded together by a suitable welding process (Fig. 1). Before the two parts A, B are welded together as aforesaid, the face 4 of the top jaw B and the face 5 of the bottom jaw and the edges of the same are preferably ground to form the cutting edges at the sides of the jaw, which grinding process is very easy, as it is performed before the top jaw B is welded on to the other part of the finger A. (*Accepted December* 30, 1916.)

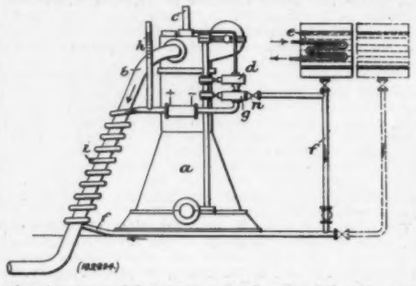
GAS ENGINES, PRODUCERS, HOLDERS, &c.

102,774. J. B. Skeoch, Wishaw. Internal Combustion Engines. (1 *Fig.*) October 3, 1916.—This invention relates to internal combustion engines furnished with forced or other pump-fed lubrication, and of the type in which in the engine lubricating circuit there is a cylinder and spring-controlled piston acted on by the oil pressure and operatively connected to parts arranged to cut out the electric ignition and so stop the engine should the oil supply fail or become exhausted. A is a cylindrical chamber having an inlet port B and an outlet port C adapted to be connected in the oil circuit. Within the cylinder A is a piston D having a piston rod F extending up through a cylinder cover G and provided at its upper end with a tappet piece H and beneath the cover with a collar J. Between the cover G and the piston D is a spring K, and between the collar J and the piston is a second spring L. The piston-rod F is free to slide through the piston, but is controlled on the one hand by the spring L, and on the other hand by a nut M on its lower end. Upon the top of the cover G is secured a block N of insulating material, on which is a bracket carrying an adjustable contact



P and a central tappet extension forming a terminal S. In a second small bracket on the block N and connected to the cover G is mounted a tappet lever W, one arm of which co-acts with the contact P and the other arm of which is adapted to be engaged by the tappet piece H. The terminal S is connected to the positive wire of the ignition circuit, while the parts of the device are, of course, earthed by their connection with the oil piping. In operation, oil under pressure enters by port B and so raises the piston D that it may flow freely out by the port C. This action raises the rod F to such an extent that it throws the lever W out of contact with the contact P. Further travel of the rod is limited by the encounter of its collar J with the cover G, and on further upward movement of the piston the rod slides through it, the spring L being compressed. Thus, so long as oil pressure is maintained the ignition circuit is preserved. When oil pressure falls, the piston falls, and with it the tappet H. At one determinate and adjustable position in the descent the lever W makes contact with the contact P. Thus at that moment the ignition is short-circuited and the engine stops. (*Accepted December* 30, 1916.)

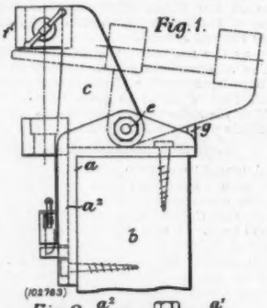
102,804. B. E. D. Kilburn, London (*Sulzer Frères Société Anonyme, Winterthur, Switzerland*). **Internal Combustion Engines.** (1 *Fig.*) September 13, 1916.—This invention provides a fuel supply system for an internal combustion engine using heavy or viscous fuel in which a quantity of heated fuel in excess of that required for immediate consumption is circulated in a pipe system and is characterised by the heated fuel being circulated in a closed system of pipes of comparatively large capacity, from which system only the part for combustion is supplied by a branch pipe to the high-pressure pump and from there to the engine. From an internal combustion engine *a* the



exhaust gases are led through a pipe *b*. The fuel valve *c* has the driving fuel supplied to it by a pump *d*. The fuel passes from the storage tank *e* into the circulation pipe *f*, in which a large quantity of fuel is maintained in circulation by means of a separate pump *g*. To the pipe *f* is connected a pipe *h*, the end of which is open to the air, and also a heating coil *i*, which is heated by the exhaust through the pipe *b* from the engine. A portion of the fuel passes to the fuel pump *d*, and thence, through a small pipe, to the valve *c* and engine cylinder, whilst the excess oil returns to the circulating pipe *f* in which pipe is provided a throttle *n*. (*Accepted December* 30, 1916.)

GUNS AND EXPLOSIVES.

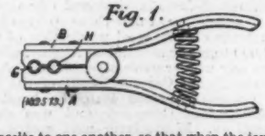
102,763. E. Jenkins, Llandaff. Gun Mountings. (2 *Figs.*) February 14, 1916.—This invention is particularly intended for the supporting of a gun from a wooden upright such as is associated with the revetment of a firing trench, and it consists broadly of two articulated metal members, one adapted to be rigidly fixed to the upright and the other to carry the gun, the latter member, when oscillated, serving to alter the height of the gun in relation to its support. The fixing bracket may comprise an angled sole plate *a* adapted to engage the top and one side of a wooden upright *b* and provided with flanges or



margins a_1, a_2 which, in addition to imparting strength to the bracket serve to eliminate side play of the pivotal bracket *c* which fits between the flanges a_1. The pivotal bracket *c* may be more or less triangular in shape, as seen in Fig. 1, with a relatively short base, the pivot *e* being located at one corner so that a pair of eyes *f* constituting a socket for the gun pivot are vertically in alignment to one side of the upright when the gun is being fired. In the other position of this pivotal bracket, which is determined by a stop or ramp *g* on the fixing bracket, the upper socket eye is preferably slightly below the horizontal (see dotted lines in Fig. 1). (*Accepted December* 30, 1916.)

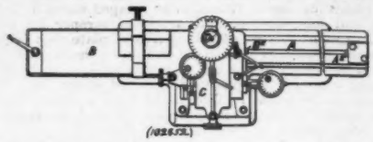
MACHINE AND OTHER TOOLS, SHAFTING, &c.

102,573. A. Herbert, Burford, and J. S. P. Cartwright, Coventry. Gauges. (2 *Figs.*) May 11, 1916.—This invention has for its object to provide a simple and quickly operated gauge for testing the accuracy, within certain limits, of screws, threaded bars and the like. According to this invention, the gauge comprises a pair of jaws A, B, pivoted together and adapted to grip the screw being tested. The gripping face of each jaw is formed with two or more recesses, and the recesses in the two



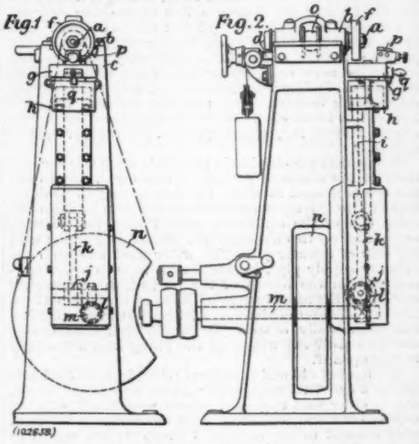
jaws are opposite to one another, so that when the jaws are closed there are formed two or more holes G, H. The holes are of different sizes, and each is adapted to constitute a gauged screw-hole. In employing the gauge, the jaws are opened and the screw to be tested is laid in one recess, say G, and the jaws closed; it is then removed and placed in the other recess H, and the jaws again closed. As the screwed holes are of different sizes the accuracy of the overall dimensions of the screw within certain limits can be easily tested. (*Sealed.*)

102,652. A. Herbert, Burford, and J. Milburn, Coventry. Angle and Pitch Measuring Machine. (7 *Figs.*) March 8, 1916.—This invention has for its object the provision of a simple machine for measuring angles, pitches, lengths and the like. According to this invention, the machine comprises a bed A carrying a table B capable of longitudinal movement through exact distances measured by the use of gauge pieces or measuring rods of known length, inserted between contact points A^2, B^2 at the end of the table and the end of the bed; and a microscope D fitted with a hair-line across its diameter and carried by



a compound slide rest C, so that it is movable in two directions by screws, the distance of movement being indicated by micrometer dials or clock indicators. When the machine is used for measuring angles the microscope is fitted with a dial graduated in degrees and fractions thereof, and an additional hair-line across its diameter which is connected with the dial so that the angle between the two hair-lines may be adjusted and accurately known. (*Accepted December* 29, 1916.)

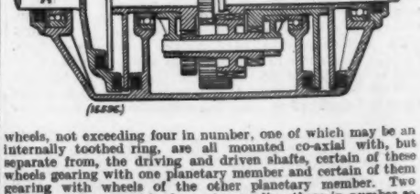
102,659. E. Williams, Edgbaston. Tool-Grinding Machines. (2 *Figs.*) March 25, 1916.—This invention has for its object to construct a machine for grinding screw-thread cutting tools, the machines being of the type in which are employed a spindle carrying a grinding wheel, one of the flat faces of which is utilised for grinding, a rotatable tool holder, and means for sliding the grinding wheel and reciprocating the tool holder. An horizontal wheel spindle *a* is mounted on a slide *b* on the pedestal *c* of the machine, and the position of the spindle can be adjusted longitudinally. Adjacent to the operative face of the grinding wheel *f* a tool-holder *g* is arranged, this being rotatable about a vertical axis and carried on a box *h* at the upper end of a



vertical slide *i*, which is reciprocated through the medium of an eccentric *j* and connecting-rod *k* during the grinding operation. The eccentric is rotated through worm gearing *l* from a shaft *m*, the latter also serving to drive the spindle *a* through pulleys *n* and *o*, connected by a belt. The portion *p* of the holder *g* which receives the tool is so constructed that the tool is inclined to the face of the wheel spindle by the amount corresponding to the clearance or relief required at the front of the tool. Also the part *p* is arranged to slide radially relatively to the part *g*, so that the tool can be fed towards the grinding wheel. The tool-holder is rotated about its axis by a handle *q*, and the amount of rotary movement that can be imparted is determined by adjustable stops *r*. (*Accepted December* 29, 1916.)

MOTOR ROAD VEHICLES.

16,596/15. D. Napier and Son, Limited, and A. J. Rowledge, London. Change-Speed Gearing. (7 *Figs.*) November 24, 1915.—This invention relates to variable-speed gear of the spur-wheel epicyclic type in which the speed variations are effected by means of clutches and brakes which are operative on certain members of the gear. According to this invention, the driving and driven shafts A, B are disposed co-axially, and to the driven shaft are connected two planetary members, so arranged that a wheel of one planetary member gears with one wheel of the other member. A set of separate



wheels, not exceeding four in number, one of which may be an internally toothed ring, are all mounted co-axial with, but separate from, the driving and driven shafts, certain of these wheels gearing with one planetary member and certain of them gearing with wheels of the other planetary member. Two clutches and a set of brakes not exceeding three in number so control the separate wheels by imparting rotation through the clutches and by locking certain of them by the brakes that power will be transmitted through the planetary members to the driven shaft, and the latter can be driven at the desired predetermined speeds. (*Accepted December* 6, 1916.)